Vol. XXI., No. 2. 1895. Whole No. 74.

PROCEEDINGS

OF THE

UNITED STATES

NAVAL INSTITUTE.

VOLUME XXI.

EDITED BY J. H. GLENNON.

PUBLISHED QUARTERLY BY THE INSTITUTE.

ANNAPOLIS, MD.

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NOTICE.

ANNAPOLIS, MD., *February* 6, 1895.

Having carefully read the six essays submitted in competition for the prize offered by the U. S. Naval Institute for the year 1895, we have the honor to announce that, in accordance with Article XI. of the Constitution, the prize is awarded to the essay bearing the motto "The best of prophets of the future is the past," on Tactical Problems in Naval Warfare, by Lieut.-Commander Richard Wainwright, U. S. Navy.

Honorable mention is accorded in the order named to the essays bearing the mottoes (1) "Le temps de guerre est arrivé," on A Summary of the Situation and Outlook in Europe, an Introduction to the Study of Coming War, by Richmond Pearson Hobson, Asst. Naval Constructor, U. S. Navy; (2) "Simplicity," on Suggestions for Increasing the Efficiency of Our New Ships, by Naval Constructor Wm. J. Baxter, U. S. Navy; (3) "Οἱ μὲν θεοὶ πάντα ἀνθρώποις πωλοῦσιν, ὁ δὲ μισθὸς ἔργον," on The Battle of the Yalu, by Ensign Frank Marble, U. S. Navy.

B. F. TILLEY,
Lieutenant-Commander, U. S. Navy.

URIEL SEBREE,
Lieutenant-Commander, U. S. Navy.

C. E. COLAHAN,
Lieutenant, U. S. Navy.

G. L. DYER,
Lieutenant, U. S. Navy.

H. OSTERHAUS,
Lieutenant, U. S. Navy.

N. M. TERRY,
Professor, U. S. Naval Academy.

J. H. GLENNON,
Lieutenant, U. S. Navy.

Members, Board of Control.

NOTICE.

The prize essay for 1895 and the essay receiving first honorable mention have been held till the present number in order to allow of a reasonable time for printing and discussion. The remaining articles receiving honorable mention will appear in the next number.

By direction of the Board of Control.

J. H. GLENNON, *Lieutenant, U. S. Navy,*
Secretary and Treasurer.

THE PROCEEDINGS

OF THE

UNITED STATES NAVAL INSTITUTE.

Vol. XXI., No. 2. 1895. Whole No. 74.

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PRIZE ESSAY, 1895.

"The best of prophets of the future is the past."

TACTICAL PROBLEMS IN NAVAL WARFARE.

BY LIEUT.-COMDR. RICHARD WAINWRIGHT, U. S. Navy.

In the study of the naval battles of the past we may learn of the many tactical problems that have arisen, and how they were solved by the great commanders of fleets; how they met with success, or the causes of their defeat. The causes are frequently obscure, as so many varying circumstances surround the tactical problem, and it is difficult to set forth the problem and its solution cleared from outside interferences. The best of tactics have failed, at times, to win success because of a change in circumstances or because of faulty instruments. And, at times, hard fighting has prevented failures that were earned by faulty tactics. Yet through all the thread of truth can be followed, and the rules that have led most frequently to success in naval warfare can be traced out for future guidance when acting under similar conditions.

The difficulty met with in discussing the problems that may arise in the future is the great change in the vessels, in the weapons and in the motive power. All have made such strides for-

ward in the march of improvement, since any great naval combats were fought, as to cause some to think that past battles can furnish no guide to the tactics of the present or future.

The first steam tactics prepared for the student in the art of war were mainly drawn from studies of tactics under sail, the necessary modifications being made to suit the change in motive power. It was evident that many of the old rules still applied; that the uncertainty produced by being obliged to rely upon the wind having been eliminated, it became possible to be more exact in the performance of manœuvres and more regular in formations. To concentrate a large portion of your force on a small portion of the enemy's was still the thing for which to strive and more than ever likely to bring success. As sail was partially a source of reliance, injury to the engines was not entirely fatal; and the knowledge of how to handle a vessel under sail was a necessity. The facility with which vessels could be handled under steam and the ease with which concentration could be accomplished gave them such an immense superiority over vessels dependent upon sail alone that it caused sails to fall gradually into disuse. Superiority in speed and in handiness were still elements of advantage that facilitated the following of the tactical rule of concentration.

The improvements now came so rapidly, and the differences between the new and the old weapons became so great that the minds of naval men were unsettled. It became difficult to draw any analogy between an old fleet and one of modern times. The tactical relations between the various weapons and between the different types of ships were constantly changing, and it was difficult, if not impossible, to estimate the tactical values of these varying quantities. Each tactician had his favorite weapon and favorite type of ship, and used a few facts and many suppositions to support his theory. Armor was placed in all positions, guns of many calibres were carried, vessels were built of all sizes and carried weapons of various kinds, and the kinds of powder and projectiles supplied were no less numerous. Some tacticians relied on ramming, some upon torpedoes, and some upon the use of guns as the principal weapons, putting the others in the background as auxiliaries.

While many of the main principles of tactics remain as unchanged as the laws of strategy, nothing is more certain than

the fact that tactics change with the weapons and with the change in their relative values as tactical weapons. Such principles as to strike immediately when the enemy is surprised, when not in battle formation, or when changing formation; to bring a large portion of your force to bear upon a small portion of the force of the enemy; and that the flanks and the rear are the usual weak points of a formation, are unchanged, and have been known since tactics were first a subject of study by naval men. But the best formations in which to carry out these maxims, and the proper evolutions to bring them into effect, change with the change in the weapons.

Sir Howard Douglas formulated an excellent system of tactics for steam vessels; but steam was at that time only an auxiliary to the sails, and the well accepted rules for sailing vessels were modified only so far as was necessary to take full advantage of the new motive power. Being no longer dependent upon the direction and the force of the wind, the formations were more elastic and the concentrations were made with more precision. The guns carried in broadside were the weapons both for attack and defense, and boarding was the only other way of carrying on a conflict. Boarding could be resorted to, except in very rare cases, only after the opposing battery had been almost, if not completely, silenced.

Shell guns came into use and were improved, as was the steam engine; but there was no cause to alter the tactics. Such was the destructive effect of shell guns that the wooden sides no longer afforded any protection to the fighting crews, and the vessels themselves were liable to destruction after being under fire a short time. Naturally a more efficient protection was sought, and ironclads came into existence. Now commenced a contest for supremacy between guns and armor that continues at the present day. Guns were built that pierced the armor, then came thicker and heavier armor, then more powerful guns. To carry the increased weights vessels increased in size, and yet the guns had to be decreased in number, and the armor had to be concentrated on vital portions in place of covering all the above-water sides.

With heavily armored vessels naturally came the idea of running down the weaker vessels; besides, the crews of the few guns and the vitals of the ship being well protected, the necessity for

a more decisive weapon led to the idea of the ram. The gun lost in relative value as a tactical weapon, and the ram came to the fore. Tactics must be changed to use this weapon to the best advantage. The enemy was no longer to be crushed with the broadside, but with the bow. It was no longer a concentration of fire but one of iron beaks that was necessary, and columns, lines and groups were urged by their several advocates.

Torpedoes grew slowly into prominence, and the auto-mobile torpedo became a weapon with which tactics was forced to deal. The large, unwieldy battle-ships with few guns, loading and firing slowly, had but little power of offense or defense against small torpedo-boats. Admiral Aube and his followers were to maintain naval supremacy by a mosquito fleet: and the tactics best adapted to torpedo-boats were the rage. The inability of these boats to keep the high sea or maintain their speed in any but smooth water soon cast a damper upon this misplaced enthusiasm, and it was recognized by most naval minds that victory would still remain on the side of the fleet of battle-ships, and that there was no cheap or easy road to naval supremacy.

Rapid-fire and machine guns, with electric search-lights, were developed as the necessity arose, and the battle-ships were again able to protect themselves near shore as well as at sea; and heavily armored vessels became necessary for coast defense as well as for sea fleets. Again the gun was raised in its relative tactical value.

The battle-ship is now fitted with torpedo tubes, and many believe that they can be used with such effect as to make an attempt to ram dangerous to the vessel making it, so that this further use of torpedoes has helped to increase the tactical value of the gun.

The cruiser has developed side by side with the battle-ship. The displacement devoted to armor in the battle-ship is devoted to motive power and fuel in the cruiser. They have increased greatly in speed, and upon the advent of rapid-fire guns it became necessary to furnish them with some protection, and we have gone from unprotected cruisers to partially protected cruisers, to protected cruisers, and to belted or armored cruisers. The latter are fit, usually, to take their place in the line of battle, and are battle-ships of great coal endurance with comparatively light armor; as, on the other hand, the coast defense vessel is a battle-ship of small coal endurance but heavily armored. The one

sacrifices more displacement to the power of making long cruises, while the other sacrifices in favor of protection.

The protected cruisers depend upon a steel protective deck, numerous water-tight compartments, minute subdivisions, with water-excluding material, for protecting the buoyancy of the vessel, and depend upon shields, etc., for the protection of the crew.

There are many vessels of special design and constructed for various purposes, and on which other weapons than the gun take the principal place. They each require their peculiar tactics to develop best the weapon they carry.

At the present day it looks as if the great strides in the progress of both vessels and weapons had ceased for a time, and that the changes to be expected in the near future are not great, but that the tendency is to settle down to fewer types of vessels and to less rapid improvements in these and in the weapons. If this is true, the tactics that are correct for the present time will remain so for a number of years, or until some new start is made in the improvement by sudden changes in vessels or in weapons. The general character of the vessels and the tactical value of the weapons may be considered fixed for our purposes.

The various changes in tactics corresponding to the changes in weapons may be traced in the writings at the time the improvements developed. Of course there is considerable overlapping, particularly at the time when the three weapons were supposed to be nearly equal in value. The more enthusiastic would seize eagerly upon a weapon early in its career, or rather in its new stage of development, and the more obstinate would hold on longer to a weapon in its decline. There were times when the gun was distinctly the principal weapon, and then tactics required that vessels be fought with their broadsides presented to the enemy. Again there were times when the ram had far the greatest number of adherents, and then they required the vessels to present their bows. The ram and torpedo required close quarters. Admiral Colomb, R. N., preferred the ram in 1871 and the gun in 1884; Admiral Fremantle, R. N., the ram in 1880 and the gun in 1886; Commander Sturdee, R. N., the torpedo in 1886 and the gun in 1894. The weight of opinion is now strongly in favor of the gun as the principal weapon.

Take two vessels equal or nearly equal in all respects. Let

one attempt to ram and let the other continue circling, but endeavoring to avoid the ram. Know thoroughly their tactical diameters for various helm angles, and plan the fight as in still water. It will require quite serious mistakes in the one that endeavors to avoid the ram before his adversary can strike a bad blow. Allow even quite a difference in speed and handiness between the two vessels, and yet how difficult for the superior to ram the inferior. Allow the inferior vessel to make slight changes in her speed, almost if not quite imperceptible to her adversary, and see where the would-be rammer will bring up. Then take these vessels under ordinary conditions of wind and sea, their speed and tactical diameter changing as they change their position relative to the wind and sea, and note the difficulty of estimating the speed or the size of the turning circle on your own vessel, and the still greater difficulty of estimating that of the enemy. Does not ramming under such circumstances become a matter of chance? Imagine the captain of a ship attempting this delicate operation from the conning tower, his view limited and partially obscured by smoke, his helmsman with no view at all, nothing to steady his helm by except possibly a small compass that is liable to jump with each fire of the adjacent guns. Most of us have noticed the difficulty, when piloting, in steadying the head of a ship if the helmsman could not see ahead and was obliged to rely on a good compass for steadying or meeting with the helm. This difficulty must be greatly increased in a conning tower, and yawing must result at a time when the slightest deviation may change a vessel from the destroyer into the destroyed. Again, there is the danger that may appear greater or less to the tactician as he has greater or less faith in torpedoes, of coming within the range of that weapon. Certainly the danger from the torpedo and the danger of being rammed instead of ramming prevents the ram from being the principal weapon.

The gun has been greatly developed in power, in range, in accuracy and in rapidity of fire. The questions that remain somewhat unsettled at the present time are the kind of powder to be used, the proportion between the length of a gun and the calibre, and the proportion of rapid-fire guns to those of larger calibre. It appears to be quite definitely settled that 13 inches is the limiting calibre of guns to be carried on battle-ships, as in

guns of this size the weight has become as great as can be reasonably carried on a man-of-war, and the time occupied in loading as long as could be permitted in battle. The largest guns must be handled by machinery, which adds another weak point to the battle-ship. Many are of the opinion that 10 inches should be the limiting calibre, and that the guns should be capable of being handled by man power as well as by steam, air or electricity. They believe that there is sufficient penetration by the projectiles of high-powered 10-inch guns at reasonable ranges, and that the reduction in weight and in time between fires more than makes up for decreased penetration.

Lieutenant Meigs, who has given so much attention to the development of gunnery practice and is one of the best authorities on the tactical value of the gun, suggests the rule that within reasonable limits the vessels should carry guns proportioned to their own protection. This rule is fairly well followed, for the heavily armored coast-defense vessel carries a few large calibre guns, and the protected cruiser numerous guns of smaller calibre. The armored vessel also carries a number of smaller guns; the smaller rapid-fire and machine guns to drive off torpedo-boats and other small craft; the larger rapid-fire guns to attack unarmored ends and to crush lightly protected vessels. In the cruiser the calibre is kept somewhat larger than required by the rule, for the sake of gaining in explosive force of the shell, the consequent gain in damage inflicted being sufficiently great, up to certain calibres, to more than balance other disadvantages.

The length in proportion to calibre has been increasing with the improvements in powder, thus gaining higher velocities, therefore greater penetration and greater range. This increase in length was made possible by adopting breech-loading devices, and requires slow-burning powders. It would seem as if it might be better to follow the spirit of the rule above mentioned more closely, and in cruisers to decrease the length of the larger guns and increase their calibre. This might be done without unduly increasing the height of the trajectory for moderate ranges, and with the larger shell thus gained the explosive force would be considerably increased. It is logical to arm cruisers to fight cruisers, and other things being equal, the cruiser throwing the larger shell would be more powerful than one armed as at present.

Smokeless powder suitable to the smaller calibres has already been manufactured successfully, and the development is in the direction of smokeless powder for all calibres. Numerous attempts, more or less successful, have been made to fire shell charged with high explosives. They have been sufficiently successful to start an alteration in the distribution of armor, causing it to be spread over a larger surface. Comparatively thin armor, that is, armor that would not stop an ordinary shell, will cause those charged with high explosives to burst outside, causing little or no damage. Improvement is to be sought in the shell more than in the character of the high explosive, as the more perfect the shell the further it will penetrate before detonating the charge.

The improvement in armor has been great, from wrought-iron to composite, to homogeneous steel, to nickel steel, and now to Harveyized nickel steel; but the improvements in the gun and in the armor-piercing projectiles have been greater. At present a peculiar point has been reached; when the resistance of the armor and the penetrating power of the a. p. shell are nearly equal, a very slight difference in the shell makes a great difference in the effect. Where a shell well formed, with perfect point and smooth exterior, will remain intact and almost uninjured after piercing the armor, a similar shell having about the same physical characteristics, but slightly less well formed, will break up with only a slight penetration upon the same armor. It would appear as if the high velocities with which the shell is driven through the armor transmits by vibrations, where there are slight inequalities on the surface of the shell, a tremendous force that disrupts the smaller mass of the shell, but is distributed throughout the larger mass of the armor plate without causing serious injury. Is there not some analogy between this fact reached with high velocities in the shell, and the importance of wave resistance when high speeds are made by the vessel? Experiments are now being made by covering the point of the a. p. projectile with some comparatively soft and readily fused metal, such as lead; the idea being to gain entry with the point uninjured, the lead being melted by the heat developed upon impact.

The modern tendency is to increase the proportion of rapid-fire guns. Where armor is carried sufficiently heavy to resist them there must be unarmored ends and lightly protected guns for

them to attack; and the larger calibre rapid-fire guns are capable of attacking all but the heaviest armor. The decision of the battle may rest with the heavy slow-firing guns, and yet it may be decided by the numerous rapid-fire guns before the heavy guns have been loaded and fired more than a few times. Guns of position are usually necessary to reduce a fortress, but no battle could be brought to a successful conclusion in modern times without light artillery.

The questions formulated by Mr. Clowes in No. 70 of the Proceedings of the United States Naval Institute are very pertinent to naval warfare, and indirectly affect tactics, as they are founded upon the consideration of the battle-ship in action. An attempt to answer them, or at least to indicate the direction in which correct answers are to be sought, is almost necessary before seeking for correct solutions of modern tactical problems.

The first question is a most important one: "*Would it be prudent for any battle-ship to go into an engagement cleared for action merely as she is generally cleared for it during peace practice or manœuvres? Is any clearing for action that is not most complete and thorough, of use as an instruction?*"

It would be imprudent evidently to go into an engagement without making all the preparations that are possible in the time allowed by the circumstances of the case. That there are many precautions omitted in the ordinary exercise of clearing ship for action we all know. I have been told of an occasion when the admiral commanding the English Mediterranean fleet signalled to his vessels one morning to report when cleared for action, and some of them did not report until noon of the next day. Some of this time must have been occupied in rigging a torpedo defense, nets, booms, etc., as the vessels were at anchor; but many things ordinarily omitted must have been done to fill up so much time. More lately, the Detroit, Commander Brownson, at Rio Janeiro, when she was to steam in and protect our merchantmen while proceeding to a wharf, against the Brazilian rebel fleet, took about two hours to clear for action. The officers and men worked hard, and everything was done that experience or fertility of resource could suggest. It was far more thorough than would be practicable in an ordinary drill.

It may be necessary to prepare for action with but little warn-

ing. Many essentials can be accomplished in a comparatively short time. By exercise these are done as a matter of routine. The men become acquainted with their stations and duties, and, being accustomed to perform the work, there is no undue excitement. The work will be done more quickly and there is less liability of omitting important particulars than if no such drill were prescribed.

It is well once in a while to make a thorough business of it; but there must be many precautions that can be taken which could not be included reasonably in an ordinary drill. It might be said that a battle-ship should be prepared at all times, at least during war or when likely to encounter the enemy, but this is not practicable; for instance, time was spent on the Detroit in rigging up and protecting ready magazines, and in adjusting caps of nose fuzes, without which it would be difficult to keep up a running fight with rapid-fire guns. It would not do to keep shell on deck in sufficient quantities for any great length of time; and as hammocks, awnings, etc., are used for the protection, the time for which they can be used is limited. Ready magazines may be constructed and properly protected. Base fuzes may do away with the necessity of shifting the cap; but plenty of work can be found to occupy the time to advantage. Protection can be extemporized for the bridge and other exposed points. The boats may be moved or more securely stowed, filled with water and otherwise protected. A longer time will thus be occupied than would be reasonable for an ordinary drill; but it would be wise to occasionally devote the time necessary to thorough preparation.

The amount of time that the circumstances have permitted to be devoted to preparation may directly affect the tactics of vessel or fleet; for without an ample supply of ammunition ready to hand it would be unwise to enter into a close running fight, and it would be good tactics to manœuvre for a distant engagement until ready magazines could be prepared.

The second question is: "*What should be done with a ship's boats upon clearing for action? Would it be prudent to hoist them all out, and leave them in tow of the steamboats, a few miles astern; or would it be prudent to expose them to the enemy's gun-fire in their position on the booms and elsewhere? Preservation of the boats and reduction to the lowest possible quantity of the splinters*

flying about the deck must be considered on the one hand; on the other hand, the possible escape of one or more boats from the effects of projectiles, and the importance, if it can be secured, of having something ready for immediate lowering, deserve attention."

In whatever way this question may be handled tactics will not be involved. It certainly does not seem wise to leave the boats astern, for the rear in an action is liable to change frequently and become the front or be in any other direction, tactically speaking. At sea it would be better to carry the boats. If there are any that are so situated that their splinters would endanger a gun's crew, and the men could not be protected from them, it would be well to put them overboard, risking their recovery at the end of the action. Ordinarily the splinters could be prevented from flying by filling the boats with water and surrounding them with their sails. It would be well to improvise protection against machine-gun fire; but in a close, long-continued action they would be rendered useless in all probability for immediate lowering. It might be wise to have a collapsible boat stowed below the water-line or behind heavy armor. Before going into action in a harbor, or when preparing for one just outside your own harbor, it would be well to send the boats to a safe place, trusting to the boats of a tender being sent if necessary.

The third question is: "*What is likely to be the effect upon a ship's anchors, of a successful attempt to use the ram? What the effect upon them, of the ship's heavy forward guns if fired nearly ahead and with some depression? Is it or is it not important that you shall be in a condition to anchor at the close of an engagement?*"

Undoubtedly a ship's anchors are liable to be torn from their place when a successful attempt to ram is made. This is one of the risks necessary to run when ramming. The bow may be smashed in or the ram twisted. It is not likely that one vessel will ram another without both receiving injuries. The chains should always be unbent when going into action, to prevent unnecessary danger. As to the effect of the heavy guns when fired with depression, it would depend somewhat upon the distance from the muzzle of the guns from the deck. The anchors should be so secured as to stand the blast if the decks can resist it. With proper securing bolts, the anchors can be lashed so as to hold as long as the decks. It may be quite important to be able to anchor at the close of an engagement. If on a lee shore

with damaged engines and bad weather threatening, anchoring may be the only means of safety; as was the case with the English fleet after Trafalgar. A spare anchor might be a most valuable thing to have at hand, but weights must be considered, and no precautions will prevent naval warfare from being dangerous for lives and material.

The fourth question is: "*Have you a thoroughly workable scheme whereby you can at once provide the proper substitute for any officer who may be killed or wounded, no matter in what part of the ship he may be stationed? Can you instantly make good the chain of authority throughout the vessel, no matter in what link it may be broken? Can you do this repeatedly? Can you do it if two or three links should break at once? Does your method of making good these breaks leave your chain dangerously weak in places, or only shorter as a whole?*"

All of these questions except the last could be answered correctly in the negative, as to answer them in the affirmative would be to expect to be able to perform impossibilities. In the various divisions and in the many parts of the ship the train of authority may go from senior to junior officer, through petty officers to the lowest in the seaman grade. It may happen that an important division or station will be left without an officer to command. Undoubtedly it will be weakened; but we can trust that there will be found among the brave, intelligent and well drilled seamen one who can carry on the fight until an officer can be found to take command or even until the action is over. It would be impracticable to be shifting stations and divisions during an action so that the most experienced officer should always hold the most important station. During a naval engagement the chain is liable to become dangerously weak as well as dangerously short, in spite of all precautions. Fighting cannot be made a safe business.

The succession to command is the most important portion of the chain of authority to preserve unimpaired. The position that the executive officer may happen to occupy at the time of an injury to the captain is a matter of vital importance. The United States Naval Regulations say of the executive, on page 119, Article 523, that "In battle he shall look after the general working of the armament, and from time to time repair to any part of the ship where his duty may be performed to the best advan-

tage." If the executive supervises the general working of the armament, his position at any one time is uncertain, and when he is wanted to assume command he may not be found readily, and when he does assume command he may have but little knowledge of events outside of his own ship, unless this regulation is interpreted, as it should be properly, to mean from the conning tower deck or bridge, except in cases of emergency. Otherwise the position of other vessels or their condition may be entirely unknown to him. This would be always an unfortunate condition of affairs, and under certain circumstances could only result in disaster. The removal of the captain by wounds or by death during action must be always quite a serious event. No matter how well the next in command may be acquainted with the scheme of action, the captain's methods, and the surrounding circumstances, there must be a short time elapse before he can hold the reins firmly. Should the ship be about to ram or be attempting to escape the ram of an opponent at the time, a slight wavering or uncertainty during the time the second brain was taking the command relinquished by the first, might be sufficient to turn a position of safety into one of imminent danger, or to turn victory into defeat. The latitude allowed by the regulations is necessary, as emergencies might arise requiring the presence of the executive in any part of the ship; but they must not be construed too liberally, for during the greater part of a battle his duties can be performed to the best advantage in positions not far from his commanding officer. The Germans station the executive, the second in command, on a lower deck, in a position of comparative safety. Here he is unlikely to be injured by the same accident that incapacitates the captain, and he can always be found; but his knowledge of passing events must depend upon such reports as he may receive from time to time, and it would take some minutes before he could act intelligently should he be called upon to assume command. The second in command should be near the captain, so as to learn from him his scheme of action from time to time. He should be able from his station to keep himself informed of the sequence of surrounding events. He should be sufficiently near to prevent any interregnum, where he could notice the fall of the captain and where he could exercise at once the command that devolved upon him. And yet he should be in such a position as would render it unlikely that both

of them should be injured at the same time, and where he can render efficient service superintending the general working of the armament. When the captain is on deck the executive should be in the conning tower, and if the captain be in the conning tower the executive should be on deck under some protection.

When piloting is necessary the navigator must be at or near the wheel to conn the ship and keep her from running aground, as the captain would probably need all his faculties to fight his ship properly. When no piloting is required he could be stationed in some comparatively safe and central position, from which he could be called readily to assume the duties of executive should it become necessary. The senior watch and ordnance officer should not be called from his duties, unless required to take the position of executive.

The fifth question is: "*To what extent do you propose to rely upon voice-tubes, electric wires for lighting, firing and signalling, helm indicators, engine-room telegraphs, etc., in action, and what provisions have you for finding substitutes at an instant's notice for any or all of them?*"

Voice-tubes or telephones are absolutely necessary for the proper command of a modern vessel. The distances are too great and the passages are too intricate to admit of relying upon messengers, and a chain of messengers is as liable to damage as a voice-tube, and the liability of errors arising is greater in the former than in the latter. The number of voice-tubes can be increased easily, and different stations arranged for their use; but the size of the crew is limited, within reason, to the berthing capacity of the ship. Some messengers are necessary, but the number of the crew that can be spared for such purposes is limited. There will be many times during war when the strain upon the crew will be great, and it might easily grow excessive if they were not properly berthed so as to be able to get the necessary rest when suitable opportunities occurred. Lighting by electricity is more in danger of interruption than by lamps; but when there are sufficient dynamos, and the battle circuits are properly run, this danger is reduced to a minimum. Lanterns should be kept filled and trimmed ready for lighting at all points where light is a necessity. Helm indicators and engine-room telegraphs add to the precision with which orders can be deliv-

ered and executed. They should always be supplemented by gongs and voice-tubes. It must be remembered that injury to the conning tower may injure the steering wheel and the communications at the same time, and that other stations must be provided with means of communication to the engine-room, and also to the tiller-room, at which place it may become necessary to steer the ship. It is extremely doubtful whether the electric control for firing broadsides is an advantage or not. It must not be depended upon; but there should be an electric signal by drop-shutter or otherwise, so that the captain may be informed when any guns are put out of action. It might modify his tactics considerably should he be informed that a portion of his guns were rendered useless. There might be great choice as to which broadside to turn to the enemy; or if sheering to increase the strength of fire, the helm to use would be regulated in accordance with the location of the damaged guns. For night signalling, rockets, Very's signals and torches would be provided always to take the place of electricity, should that means of signalling fail.

The sixth question is: "*How much more or less complicated and delicate gear have you in your ship upon which you would not think of depending if you were going into action? Do you use it at present? Is it wise to use it if you would not think of depending upon it?*"

This question appears to refer to the subjects of the fifth question already considered. All methods of signalling, securing communication with the various parts of the ship and operating the machinery should be as reliable as possible and the same used under ordinary circumstances as would be used in action. This is necessary to secure familiarity with the gear and reasonable certainty of working in time of battle. Simplicity and strength should be sought for; but it must be remembered that a ship of war is a complicated machine, and that there are of necessity many parts which are delicate and liable to be injured. To multiply these unnecessarily would be a serious mistake, but there are few machines more complicated or more delicate than man himself, yet his services are indispensable. A compromise on this question as well as on many others that arise in the consideration of a man-of-war is necessary. There has been a tendency abroad, but not at home, to sacrifice too much of the strength of moving parts in order to economize weights. Guns

may be handled more swiftly and accurately by machinery than by hand, and yet a damaged man may be replaced when it would be impossible to replace or repair the machine. Where to draw the line will always require anxious thought and numerous experiments. The tendency will continue to be in the line of an increase in the amount of machinery for replacing hand power as improvements are made and designs perfected.

The seventh question is: *"What provisions have you for making or answering signals in action? Have you any protected station for your signalmen?"*

The ordinary provisions for signalling in action are quite inadequate, and in no direction is improvement more necessary; but whatever method may be used, shapes, semaphore, or flags, protection must be provided for the signalmen. In some of the accounts of the Yalu river fight it is stated that the Chinese were obliged to remain in their weak formation because all the signal halliards were cut early in the action. It may be believed that this was not the only reason for the helplessness of the Chinese fleet, but it must be recognized that as signals are necessary for the proper handling of a fleet, protection for the signalmen, at least, must be provided against machine-gun and small-arm fire.

The eighth question is: *"What effect may be anticipated should a hostile projectile strike a fuzed shell in your racks, or a charged torpedo? How does a knowledge of what may happen in such an event influence your arrangements for keeping up a supply of ammunition to your more exposed guns, and for using your above-water torpedo tubes?"*

If a projectile should strike a fuzed shell it would be very likely to explode; but there is no reason why the remaining shells should explode. Not very long since an army caisson exploded and some of the shells must have been exploded by the concussion of the others; but it is probable that they were badly fuzed, and such an accident is not liable to happen with the navy fuze. Under any circumstances it is necessary to have a supply of ammunition for your guns, and the risk must be run, only it can be narrowed as much as possible by using permanent or improvised protection.

The reservoir of a Whitehead torpedo would make quite a serious explosion if struck by a projectile, and it is probable that both the Howell and the Whitehead charges would be detonated

by an exploding shell, if not by the concussion of a projectile. For this reason it is unwise to carry charged torpedoes in unprotected above-water tubes, as they may possibly prove more damaging to your own vessel than to the enemy. Of course this refers to battle-ships and to cruisers, not to torpedo-boats.

The ninth question is: "*How would a suspicion that your bow tube might at the moment contain a live torpedo influence your decision, should an opportunity for ramming present itself?*"

My bow tube would not contain a live torpedo so long as the motive power of the ship remained uninjured. A bow tube is of little value on a battle-ship. It should only contain a charged torpedo when the motive power has been so impaired as to render ramming impossible and being rammed probable, and then the bow would be the least useful place to have one.

The tenth question is: "*Is there from your battery-deck an up-draught which would quickly free the battery from the gases of any explosion that might occur there? What consequences are to be apprehended there or elsewhere from the gaseous products of certain high explosives?*"

The first part of this question evidently refers to the earlier type of battle-ship. It is hardly probable that much of an up-draught could be procured. From the experiments with modern high explosives it is hardly probable that many would escape the effect of the concussion or of being asphyxiated by the explosion of a shell so charged in a casemate or other gun enclosure.

The eleventh question is: "*Can you get in your torpedo-net defenses sufficiently to enable you to manœuvre your ship, without the necessity of employing your men outboard, in such a manner as to mask much of your own gun-fire, as well as to expose the men to the fire of the enemy? If not, do you purpose, in war-time, to ever use your net defenses when you are liable to sudden attack?*"

No known net defense can be rigged in securely without exposure of men and important loss of time. The torpedo-net is mainly useful when coaling and repairing within the radius of the enemy's torpedo-boats, or when attacking a harbor where there is no liability of being attacked in return by other battle-ships. It would be criminal to use them when able to steam and liable to be attacked by other ships.

The twelfth question is: "*Do you realize the continuous nature of the strain likely to be put upon executive officers by the conditions*

of modern warfare? Have you ready any scheme whereby this strain may be as much as possible equalized, and whereby both officers and men may husband their strength and nervous energy to the best advantage? For how long do you consider that a crew could stand the wear and tear of maintaining a position, say within fifty miles of a great port in which lay a hostile fleet and a large flotilla of torpedo-boats?"

If you have a properly organized force, with a reasonable proportion of cruisers and torpedo gunboats or catchers, you can, by making proper tactical dispositions of your forces, prevent any excessive strain upon officers or men. In fact, in no other way will a tactician have a better opportunity to show his ability than in so disposing his vessels as to prevent sudden alarms and undue tension from being inflicted upon his entire fleet. In the daytime, except in foggy weather, and even in bright nights, but few lookout vessels would be necessary to prevent a surprise; but on dark nights and in thick weather it would require all the cruisers and gunboats to guard the battle-ships, and numerous lookouts would be necessary on all the vessels of the fleet. The circumstances may be too varied to admit of fixed rules, and with only a small proportion of unarmored fast vessels the strain must be great under any circumstances. If fifty miles away, the battle-ships can cruise under low steam, or remain at anchor, with heavy banked fires, during the day in clear weather or during bright nights. The hostile port must be watched closely by three or four light vessels, the number depending upon the size and character of the entrance guarded. At night these outguards must be cautioned to examine headlands, wooded points, etc., as closely as the enemy's batteries will permit, to prevent torpedo-boats from sneaking along the land. Outside of these, in a central position, within easy signal distance, the main guard of torpedo-catchers must cruise at night. In the daytime one or two cruisers to pass back the signals can take their place. Within five or six miles of the fleet again will be stationed two or three torpedo-catchers, to watch for torpedo-boats that may have passed the outguards. Between the fleet and the inguards the main body of inguards will be stationed at night. The guards of the night previous will be stationed where there is the least chance of their being subjected to sudden attacks. If the position being maintained is a harbor, the mouth will be closely

guarded and the fleet anchored so that it can steam out and be drawn up in battle formation at a point where it has ample sea-room, soon after the notice of the movement of the enemy's heavy vessels. It would only be practicable to thus maintain a point fifty miles from a hostile fleet, when it was only necessary to watch and keep in touch with the fleet of the enemy. But if masking or blockading the enemy's fleet, it would be necessary to hold the fleet nearer the hostile port and to be kept underway at all times. Then the point fifty miles away might be maintained for coal, ammunition and other supplies and for repairs. In foggy weather the line must be drawn more closely around the port, and the main guard should join them in picket duty. The work would then become most arduous, and signals must be carefully arranged to prevent the attacking of friends. The cruising ground must be carefully laid out to prevent the necessity of too frequent signalling that would betray the whereabouts of the guard to the enemy. Sound signals only would be possible, and they could be changed from time to time, using the steam whistle, the boatswain's call and the bugle. If a harbor is the point maintained, picket-boats and torpedo-boats must swarm at the entrance. It would hardly be possible for the enemy to make an attack with his heavy vessels in a thick fog, and if he did, the torpedo-boats and torpedo gunboats should be able to defeat him. If the point were an open roadstead, it would be practicable to anchor the fleet when there were ample torpedo-boats for protection and when the weather was suitable for handling them. But if the sea were too rough for the boats, the fleet should stand out from land at a moderate speed, followed by the cruisers and gunboats in a formation with a broad front, and running out for an agreed upon length of time, then upon the signal being made, standing in at a slow speed with the cruisers spread out in front. A column of cruisers should connect the line of cruisers with the battle-ships, to pass sound signals and to keep touch in the fog. In this way of disposing the vessels the strain should not be excessive, unless an inordinate amount of foggy weather is encountered, as the greater fatigue would fall upon the younger officers and men who should be more able to endure it, and being in the smaller boats could be the most readily relieved, and would be from necessity more frequently relieved for coaling, etc.

Should you be blockading the port or masking the fleet it would not be practicable to closely guard the enemy during foggy weather with the heavy vessels. For if he can feel his way out he can keep in close order and attack everything he sees or hears, and when separated make for a pre-arranged rendezvous. With the use of torpedo-boats and torpedo gunboats his attempt to escape could be made highly dangerous, if not impossible, and the heavy boats should be kept well off the port.

The thirteenth question is: "*What will be the effect upon the occupants of a conning tower, even if it withstand the blow of a heavy projectile,* (A) *from the concussion,* (B) *from the displacement of the fittings? Should a commanding officer attempt to fight his ship from the conning tower? If not, how should she be steered, and from what position can the captain enjoy the necessary view, while still maintaining communication of some sort with his officers?*"

The question of the conning tower is a most vital one. It has been discussed partially already in the question (No. 4) about maintaining the chain of command. We have some previous experience from which to judge, viz., the reports of the commanders of our monitors during the war. They all spoke of the difficulty of handling their vessels with the limited view afforded by the conning tower, especially during the smoke of battle. The effect of concussion can only be estimated. Wooden mantlets prevent direct contact that would be fatal at the time of the blow, deaden the force of the concussion by the intervention of an air cushion, and prevent injury from flying bolts. A vessel might be well handled from the conning tower, provided it were well constructed, if it were manœuvring against one vessel only; but if the vessel were in a fleet, or were manœuvring against several vessels, it is difficult to imagine how the captain could obtain a sufficiently all-around view to fight his ship from the conning tower. There would be little likelihood of the same commanding officer being able to carry through an engagement unless he were afforded some protection, for without it he would be sacrificed, probably, at close quarters, at a time when it would be most disadvantageous to change the officer in command. There should be several protected stations, at least one on each bow, from which the captain could fight his ship. These stations must be clearly visible to those inside the conning tower, and

they should be connected with the conning tower by gongs, telephones or indicators, or by all. They should also be connected with the steering station in the tiller-room and with the engine-room. The captain could communicate by signs with those in the conning tower under many circumstances, but must be able to have recourse to other methods at times. The conning tower should be accessible from the deck, so that the captain can enter when desirable, and his officers and messengers can leave it to communicate directly with him. Even with all these facilities, to accurately handle the ship he will require great experience under service conditions. The captain, the officer at the conn, and the helmsman must work in unison. The finest display of the seaman's art will be the handling of a battle-ship in action. Seamen are more than ever necessary, and without a high order of intelligence, guided by experience, the immense ship, with its numerous guns, powerful engines and intricate machinery, will be wasted in the combat.

The fourteenth question is: "*To what extent, if any, can glass over dials, lamps, lanterns, etc., be depended upon in the event of a heavy explosion in its vicinity? To what extent, if any, can horn or talc be substituted for it? Is it advantageous, or otherwise, to have a brightly lighted battery on the occasion of a night action?*"

The first portions of this question might well be the subject of experiment, and could be exactly determined without difficulty. Thicker glass than used ordinarily might be found advisable where it was practicable to sacrifice some of the light. The last portion of the question can have but one correct answer. No one who has had experience on board ship, who has looked out of a lighted pilot-house or chart-room at night, can fail to answer in the negative. The gunner's view is frequently seriously limited in the daytime; at night from a brightly-lighted battery he would see hardly anything, and to bring his sights on anything but a brightly-lighted object would be an impossibility. Only so much light as is necessary for loading the guns and setting the sights should be used, and that should come from behind the gunner, and care should be taken that it is not reflected from the side or from the gun into the gunner's eyes.

The fifteenth question is: "*Will it in all cases be advantageous to use smokeless powder? What provision is there for the production of smoke should it be needed to serve as a screen to leeward?*"

A battle-ship must have a clear view, and therefore under most circumstances must be seen, so that smokeless powder prevents being taken unawares by the enemy and mistaking him for a friend, as well as giving a clear target for the guns. There have been several smoke-producing inventions for army use that might be useful in preparing for an attack to be made by your own torpedo-boats. All the smoke needed can be produced also by a raft with a burning tar-kettle.

The sixteenth question is: "*What are the possible defenses of a ship underway, against a torpedo that is approaching her? What is her safest position* (A) *if moving slowly,* (B) *if moving at speed, supposing that she cannot in time move out of the line of fire? What is the effect upon a torpedo of the explosion of a heavy charge under water within a short distance of it? What provision have you for the explosion of such a charge at short notice, in or near the path of an advancing torpedo?*"

Under the circumstances mentioned, the helm and rapid-fire and machine-guns are the means of defense. If a vessel is moving rapidly and cannot move out of the line of fire in time, her safest position to receive the torpedo is bows on, and stern on if moving slowly. With speed the bow wave would be more apt to deflect the torpedo; it should be taken slightly on one bow where the wave forms less than a right angle with the keel. Going slow, the wash from the propeller would be more apt to deflect the torpedo, and it should be taken slightly on one quarter. While heavy charges exploded in the immediate vicinity would probably explode it by concussion or deflect it, it would seem as if it were impracticable to have heavy charges ready at the appropriate places, and the chances of hand grenades being effective seem too few to warrant their presence about the deck.

The seventeenth question is: "*If your funnels be seriously damaged by projectiles, what speedily available provision can be made for the maintenance of a reasonable amount of draught?*"

This has become a more important question lately than it was when more dependence was placed on forced draught. The modern tendency to rely on increased length of funnel for draught has increased the weakness of that feature and has made the injury of the enemy's funnel an important tactical consideration. The enemy's speed might be greatly reduced by the fire of the rapid-fire guns. Small injuries might be repaired by

a species of soft patch, but the heat developed at the lower part of the funnel above the armor case is usually too great, when going at high speed, to permit the use of temporary expedients, and the main reliance must be placed upon forced draught. Besides the loss of draught, the escape of smoke and cinders, at a slight elevation above the decks, might interfere seriously with battery and helm.

The eighteenth question is: "*If you decide to ram, at what speed will you steam, and how will your decision be affected by the direction in which the enemy is moving? Will you or will you not reduce speed, upon making or immediately before making contact?*"

The ship's best speed is the proper speed to make when attempting to ram, that is, not a spurt that may give out before reaching the enemy, but the highest steady speed that can be counted upon to continue during the manœuvre. Then smaller angles of helm will produce greater effect. It would be well to shut off the steam upon making contact with the enemy when striking him on or nearly on the broadside, otherwise it would be well to notice the effect of the blow before stopping the engines. You might escape with less injury after delivering the blow if the pressure was continued than if it was shut off from the engines.

The nineteenth question is: "*Having sustained serious underwater injuries to her forward part, should a ship be steamed ahead or astern in order to run her into shallow water?*"

Here again the seaman must be guided by the circumstances attending the case. If the water-tight bulkheads will stand the pressure, it is advisable to steam ahead into shallow water for several reasons. The ship can ordinarily be handled more easily when steaming ahead. Collision mats, etc., that would be put over the bow, when practicable, to lessen the leak, would be of little or no use when steaming astern, but would be held in place by the pressure when going ahead. Unless the injury at the bow had caused the draught forward to increase seriously, it would be advisable to ground the ship bows first, for otherwise on a steep-to beach the sinking of the bow might drag the ship off into deep water. The injury might be so serious as to make the bulkheads remaining unable to stand the weight of water with the additional pressure caused by steaming ahead, in spite

of all possible efforts to support them; then it would be necessary to steam astern into shoal water.

The twentieth question is: "*To what extent does the principle of the isolation of heavy guns as carried out, for example, in the Royal Sovereign, Almirante Tamandare, etc., conflict with the control by the captain and by the battery-officers of the ship's gun-fire? Can any disadvantage which might arise, owing to this isolation, be neutralized by the issue beforehand of general orders?*"

The captain will only be able to have a very general control of the battery, heavy guns and light, unless it is deemed wise to indulge in broadside firing by electricity; but they will be under the charge of the officers of divisions, and the captain will give them general and special instructions for their guidance. When practicable, the heavier guns will be aimed by junior officers. The captain will inform his divisional officers of his general intentions, tell them how he proposes to carry on the action and at what range he proposes to open fire with the different calibres; in other words, will give them tactical instructions. In fleet, he should be able to designate at which opponent they are to direct their fire, and he should designate the various parts of the enemy's vessel as targets for each calibre, and see that the officers understand how to change the point aimed at according to the construction of the enemy's vessel. He must have some means of communicating with all the divisions, so as to direct them to open and cease firing, to give them the range, and when they cannot observe the fall of their shot, let them know if they are raising the sight-bar too high or dropping it too low. He must know from them when their guns are disabled.

The twenty-first question is: "*To what extent does the principle of closed water-tight compartments conflict with the communication of orders to various parts of the ship, supposing voice-tubes, wires, etc., to be dislocated or unserviceable? How is the difficulty to be provided against?*"

This will depend largely upon the construction of the ship; but any modern-built battle-ship will be in very bad circumstances when all means of communication, except by messenger, have been cut off. At some points doors must be left open, at others messages may be passed through traps in the doors; but it would be wise to have several points or centers of communication and separate lines of tubes and wires to lessen the chances of complete interruption of communication.

The twenty-second question is: "*What provision is there for the prompt removal below of wounded men, without undue interference with the continuous transport to the deck of ammunition, and with the passage of messengers, etc.?*"

This question must be answered separately for each ship according to its construction; and to provide for the care and transportation of the wounded without interfering with the service of the guns must be a matter of anxious thought. In an action of any length of time, other men will be wanted besides the usual aids to the wounded, or the guns may be left without men.

The twenty-third question is: "*Of what use to an officer, especially one employed below, is a sword? Should any officer upon going to general quarters wear a sword? Would a couple of revolvers, supplemented perhaps by a short, heavy, pointed weapon, shaped like the Roman sword, be more useful?*"

This is not a matter of great importance. Every officer should carry some symbol of authority, and a sword is one easily recognized; and some means of immediately enforcing authority should be in every officer's hands. A revolver would answer this latter purpose very well. One revolver is enough for any ordinary man to manage, and an officer would not look well weighted down with weapons. Little niceties of uniform and etiquette have much to do with the preservation of discipline without friction. The design of the sword should be such as to be suitable to all occasions, so that an officer may have it at hand always when on duty. A rapier has been suggested by some, one of medium length, as it is easily kept ready for service, is less apt to become a mere useless ornament, and at the same time is well suited to dress occasions.

The twenty-fourth question is: "*Are you prepared with any scheme whereby, even at risk to your ship, you can take on board, while underway, at least some coal, if such a proceeding is desirable? Do you habitually complete with coal in the shortest possible time, and is it desirable that when coaling you should do this?*"

No satisfactory method has yet been found for coaling at sea. The only method at all practicable in a seaway is by trains of coal-bags between the collier and the ship, one towing the other. If the collier is heavy enough the ship can be towed astern, and if an accident should happen, the greater injury will happen to the one of smaller value; besides, if the bags should dip in the sea,

the wash on them will help them toward their destination, in place of being a drag. If the collier were too light it would be preferable to tow her on the quarter, using spring as well as tow line. The arrangement of the runners would depend upon the relative heights of the two vessels, and they could be rigged easily by a skillful seaman. The problem of re-coaling rapidly is almost as important as that of repairing rapidly, and countries with large fleets will have colliers with coal elevators for rapid coaling in smooth water.

Under most circumstances it would be wise to coal in the shortest time possible, and the duty should be performed with the exactness and promptitude required at a drill, for much may depend upon the rapidity with which the vessel is coaled, and the dirty work has a demoralizing tendency upon discipline and should be completed as soon as practicable.

The twenty-fifth question is: "*What are the advantages and dangers attendant upon the use of the electric search-light against an enemy? Where should a search-light, if used, be projected from? What is its effect upon the sight of your own people? What its effect upon the sight of an enemy? To what extent can the projected ray be used as a screen? Are you prepared with any better method whereby an enemy's ships or works may at night be rendered visible to your gunners?*"

The electric light permits you to search out your enemy in the dark, and at times to blind his sight, preventing officers of torpedo-boats from judging your distance correctly and the gunners of the enemy from pointing their guns. A search-light for picking up torpedo-boats should be as low as possible, but it should be in rear or to one side of your guns. The two requirements are difficult to reconcile, and positions for the lights must be selected according to the arrangements of the ship.

The light may be used improperly and dazzle the eyes of your own people or serve as a guide to show the enemy your position. It may be used as a screen by being thrown into the eyes of the enemy's gunners. It must be remembered in a fleet that you may blind friends as well as enemies, and may cause confusion by crossing the beams. Rockets and fire balls have been proposed to take the place of search-lights for illuminating an enemy's ships or works; but they are better adapted to being used from forts than from ships.

The twenty-sixth question is: *"Is any range-finder as practically useful and quick, in daylight, as a rapid-firing gun? Would you use any other in action?"*

The rapid-fire gun is the best range-finder for the larger guns if it is in the hands of an excellent marksman; but the range-finder would be most serviceable to help put the rapid-fire gun on the target, to check the gunner, and to determine the rate of change in range when the vessels are moving rapidly. The great advantage of using the rapid-fire gun as a range-finder is that for the guns you do not wish the exact range, but the apparent range. The low trajectory of modern guns makes this less necessary than formerly; still it must be taken into account that it would be a strange state of the atmosphere when there was no refraction.

Having considered the various tactical details involved in the preparation of a battle-ship for action, the next tactical problem in order is the combat of two ships. This is one of the simplest problems of battle tactics, and yet there are so many points that may arise under so many varying circumstances as to make it possible, within reasonable limits, to consider only the more prominent phases of the combat. As the gun is considered as the ruling weapon, both for offense and for defense, the object of the manœuvres will be to have as many guns as possible bearing on the enemy, to keep within fair range, to avoid unnecessary waste of ammunition, and to allow him to use as few of his guns as possible.

Two vessels meeting on approximately opposite courses, and both being ready for the combat, the first point to decide would be the time to open fire. It is pretty generally conceded that 4000 yards is the extreme opening range; for greater ranges the probabilities of hitting are too small to warrant an expenditure of ammunition when the limited supply that can be carried is remembered. Still as two ships approaching at the rate of fifteen knots each would lessen the distance by one thousand yards a minute, the time of distant firing would be too short to make early firing a serious mistake for rapid-fire guns. With heavy guns the time occupied in loading and training becomes an element of importance. At the speed mentioned, two vessels distant four thousand yards would meet in four minutes. Now, at short range the probabilities of hitting become so much greater

than at long range, and where armor must be pierced the damage that can be inflicted is so much greater, that it becomes important to be able to fire at close quarters. The time elapsing between fires will differ among the heavy guns according to their calibre and mount; but it would seem safe to fire one round from about four thousand yards, and then loading at once, reserve the next round for close quarters if the vessels are drawing together rapidly. The opening range being too great to admit of piercing the heavy armor of a battle-ship, shell should be used, and the unarmored or lightly armored portions of the enemy should be the target. At close quarters a. p. projectiles would be used. Of course when firing at unarmored vessels common shell would be used at all ranges.

As the two vessels approach each other, one, if not both captains will see the advantage of employing as many guns as possible, and will use the helm to present the broadside. If the idea should enter the minds of both captains at the same time, the chances would be even as to whether they would use the same or opposite helms. When one ship has indicated her intention to sheer off the course, the other would naturally use the opposite helm, so that the ships' heads would be turned in the same general direction. Any other direction would indicate that the latter was not desirous of continuing the fight and was ready to draw off for a time, if permitted. So that naturally the vessels would tend towards each other, and when at fairly close range tend to take up parallel courses. Unless willing to enter into a ramming contest, the enemy must not be allowed to draw too close.

We may meet with an enemy who is determined to try his ram. He will endeavor to keep his ram directly on our bow. If we turn in ample time we will be able to fire more guns than he can and yet prevent him from occupying a position of advantage. Lieutenant Bethel, R. N., has pointed out the position of danger. It is having your enemy at such a distance astern that your reduced speed will permit him, by following the chord, to reach a point upon your circle at the same time you do; in other words, to ram you. This distance astern varies with the speed. While you might be able to extricate yourself from this position, it is one where you are in danger of being rammed; and usually, as bow fire is generally stronger than stern fire, he would have

the advantage in guns and might damage your steering gear or your propeller.

The part of the ship towards which the attack should be directed is a point of considerable importance; it depends upon the design of the ship attacked and the relative position of the two vessels. When first opening fire the vessels will be bow on or nearly so, and from necessity the target would be limited to the forward part of the ship; but when the broadside of the enemy is exposed the target is more ample. For battle-ships the heavy guns loaded with a. p. projectiles will be used against the midship section to injure the motive power by piercing armor and striking engines or boilers; the secondary battery against unprotected or lightly protected gun crews. Smaller rapid-fire guns may be told off to injure the funnel, and by reducing the draught cut down the speed of the enemy. The small arms and machine guns will search all openings if at really close quarters. The guns in tops will pay attention to guns mounted in barbettes.

It may be found when broadsides are bearing that sufficient damage has been done already to the unarmored bow of the enemy to make it advisable to ensure considerable damage by continuing to use it as a target. The bow compartments being filled with water, the speed will be decreased by the increased resistance of the bow and the decreased immersion of the screws, and the ship will be more difficult to handle. A portion of the screws and rudder may become exposed and a well-placed shot leave the vessel an easy prey to the ram. Many of the older battle-ships have no protection for their secondary battery, and these must lose much of their power early in the combat. Some are still armed with muzzle-loading rifles for their heavy guns, and these guns would be silenced when within machine-gun range.

For cruisers the location of the battery would seem to be the most important target, for with the destruction of the guns' crews the principal sting of the cruiser would be drawn. In many cruisers there is the same danger of being raked as in the old sailing ships. At the latter part of the action, or at any time when liable to come to close quarters, it may be well to direct a certain portion of the lighter rapid-fire guns at the above-water torpedo tubes. There have been built certain cruisers that it

would be wise to attack at the water-line, especially if the sea is not smooth, for they are liable to extreme lists with the admission of a comparatively small quantity of water above the protective deck. Properly protected cruisers using cellulose, cork or other water-excluding substances, and with reasonable metacentric height, should be attacked about the battery.

The object for which the engagement is fought will have some weight in determining the tactics to be pursued. The most fruitful source of single combats will be the meeting of scouts. A fleet starting out with a definite object will endeavor to cover its movements with a number of scouts, as an army does with cavalry. The opposing fleet will push out scouts to gain information. An attacking fleet without speedy cruisers loses the advantage of its mobility, as the enemy readily obtains warning of its intended movements. A fleet acting on the defensive, without an ample number of cruisers, is liable to find itself in the wrong place when its services are wanted elsewhere, and that the enemy has succeeded because his intentions have remained hidden.

Scouts must press home for news, and their main object when forced into a fight is to temporarily disable their enemy so as to avoid pursuit; whereas it is the object of the enemy to capture, disable or drive back the opposing scout. A scout after information would be instructed to avoid combats when possible. On the other hand, a covering scout will offer battle on most occasions, even risking an attack on a more powerful vessel. Therefore when scouting for information, and not seeking a decisive engagement, the hull would be the target, for with one or two of his enemy's bow compartments filled he could easily avoid pursuit. The covering cruiser would desire a decisive result, as each scout captured or thoroughly defeated is one removed from his path, one less chance of betrayal.

Should you be inferior to your enemy in battery power, and not his superior in gunnery, you would be forced to attempt ramming. It is not very difficult to draw many curves on paper representing the paths of the ships in smooth water and show how a successful ramming encounter may be conducted; but the tactical diameter, speed and handiness are so changeable under the effects of sea and wind that they can only serve as general guides and permit us to pick out the main principles to be followed. If in moving in an opposite direction you pass the enemy, turn

toward his stern, not away from it. Get inside his circle if possible and keep him outside of your circle. If astern of him, and not so far away as to permit him to complete sixteen points before you reach his circle, you should be able to ram him. Inside of your enemy's circle he cannot ram you, and you may ram him. Beyond these rules all must be left to the eye and hand of the seaman. He may know all that his vessel will do in smooth water, and he may have studied the theory of ramming for years, but unless he has a quick eye, with ready decision, guided by experience, he will make a miserable failure when trying to put his theories into practice.

The consideration of a fleet in action naturally follows that of the combat between two ships. In discussing a fleet engagement it becomes necessary to consider what manœuvres are possible or advisable during the combat, and by what method the use of the weapons employed can be best developed so as to carry out the tactical maxims already mentioned, the most important being to so handle your fleet as to concentrate a superior portion of your force on an inferior portion of the enemy's force.

Admiral Colomb says: "I think you must look back to the tactics of a former age as the only foundation on which you can prepare your future tactics." Also, "The doubling now is that two or more ships should pass one ship and give her broadside after broadside or torpedo after torpedo, and thus double on her in succession and not in position."*

In regard to the possibility of attempting evolutions during an action, Admiral Boys says: "The conclusion was that there was no impediment to the gun fire from the smoke whatever, and I think ships going at that speed (8 or 9 knots), in a general action, will find very little." With a speed of from 12 to 17 knots there will be still less difficulty encountered from smoke, and to have it hang about the fleet the wind must be quite fresh and come from a direction nearly astern. It is evident that the formations to be used, and the evolutions to be performed with the necessary signals, should be as few and as simple as possible.

Assume two fleets approaching on opposite courses, A in echelon and B in line (1, Fig. 1). A turns to starboard (2, Fig. 1), in order to develop the fire of the battery and to threaten B's left flank. Should B continue on the original course, A, when

*Journal of the Royal United Service Institution, 1886, p. 227.

clear of B's left flank (3, Fig. 1), can reform echelon, vessels turning to port (4, Fig. 1). Here it is plainly manifest that having for a time its broadside fire opposed to B's right ahead fire, A has the advantage; and as it draws towards B's left flank the fire of one after another of B's fleet is shut out by its left-hand neighbor, until all of A's fleet are opposed to the one vessel on B's left flank, and B's left flank has been doubled upon.

The disadvantage to which B is put by these manœuvres of A is so manifest that even the most rabid against tactics would hardly fail to attempt a counter-evolution, only not believing in tactics he has more than an even chance of undertaking to make the wrong move. B might attempt to develop his fire by forming column, the vessels changing course eight points to starboard (3, Fig. 2). This would be in the nature of a retreat. A would wait until B's fleet bore abaft the beam (4, Fig. 2), and then follow in chase (5, Fig. 2). A should not alter course at once, as that would give B the advantage of fire, but by following after, A can concentrate fire on B's rear vessels.

B might develop his fire by forming column, vessels turning eight points to port. Then he would have a slight advantage of fire, as A would be attacking on a diagonal; but unless B slow down, his rear would be exposed to A's fleet; and should he slow, A might charge at full speed, vessels turning four points to port; or A might slow and change direction of column so as to run parallel to B's direction.

B's best move would be to form echelon, vessels turning to port (2, Fig. 3), threatening to charge and keeping his vessels headed toward A's fleet. When near A's vessels he might form column, vessels turning to port (4, Fig. 3), thus gaining a slight advantage of fire and forcing A to change direction (4, Fig. 3). Or he might continue his course, forcing A's vessels to turn to port and receive his charge through. Should he do this, A will have had the advantage of fire up to the time of turning for the charge.

The advantage will be always in the favor of the fleet formed for battle in echelon, if correctly manœuvred against a fleet formed in line, although it will not last for a long time with vessels steaming at the rate of fifteen knots if B's fleet is also manœuvred correctly. Echelon is a formation which if vessels hold it is difficult to double upon any of them, either in succession or in position.

With B's fleet formed in column (1, Fig. 4), A would continue his course, having the right ahead fire of his six vessels opposed to the right ahead fire of B's leaders. A would turn in time, vessels turning sixteen points to the right or left, and then have the stern fire of his six vessels opposed to the right ahead fire of B's leaders. This might continue until B's leaders were disabled or until he tired of the attack under such disadvantages; and then A would assume the attack. A might decide to develop his fire at once by forming column, vessels turning to starboard (2, Fig. 4), then again to starboard, developing broadside fire, and again to starboard in retreat (4, Fig. 4). Thus always having the right ahead or right astern, and part of the time the broadside fire of his fleet opposed to the right ahead fire of B's leader.

Should B change direction to port when A formed column from echelon (3, Fig. 5), A could parallel B's direction by changing course or direction of column; or by forming echelon, vessels turning to starboard (5, Fig. 5), keep his line of fire across B's direction. B might change course to make less than a right angle with his former direction, so as to strike somewhere near the center of A's column. Should A find that B's leader was damaged seriously by the concentrated fire of his fleet, he would change direction in time so as to run parallel with B's fleet, and thus hasten the conclusion of the action, but otherwise he would prefer to turn in retreat when B's leader approached his column, so as to continue for a longer time his advantage of fire over B (5, Fig. 6).

After A has turned to starboard, B might change direction to starboard (Fig. 7). Then A might pass in parallel or nearly parallel lines his leader, changing direction when clear of B's rear (5, Fig. 7), being satisfied with a short advantage of fire over B. Or he might turn about, keeping his advantage longer, and then continuing the fight by running in parallel lines (5, Fig. 8), unless B could force a charge.

Should A be in line with B in column, the evolutions would be practically the same as above where A is in echelon. Even should A, when in line or echelon, continue his course, permitting B to charge through, B's fleet would be at a disadvantage, for the leader would be damaged and might be disabled by the fire of A's six vessels before reaching A's line, and his leader,

with those immediately behind, would be in danger of being rammed, having vessels on either hand. Admiral Fremantle, speaking of an attack in line ahead (column), says: "When, for instance, should the leader be rammed, the rest of the squadron must be huddled up in a heap on top of her."*

It would seem impossible almost for the leader to escape damage and the column to escape being thrown into confusion.

It now becomes necessary to discuss what can be gained by the advantage of fire, and here as in single vessels we can first look to history as a guide. For even with the immense changes in ships and weapons since history has had to deal with sea fights, something of probable results may be gathered from its pages. Since guns were used first in sea fights, the motive power and the crew have been the principal objects of attack. Destruction of the vessels by sinking or by burning has been only incidental. The slaughter of the crews of the vessels composing the fleet has settled the result in the large majority of cases. By injury to their spars and sails their power of manœuvring was destroyed, and this permitted their more skillful or more fortunate antagonists to take up a position on bow or quarter, and bringing their broadsides to bear against a few guns, to slaughter the men on the unfortunate vessels.

The first use of iron armor was to protect the crews working the guns and the engine propelling the ships against shell fire. This only afforded the same kind of protection against the more powerful guns that the thick wooden sides did against the guns of inferior energy. In the accounts of many of the sea fights you read of the shot sticking in the sides of wooden ships as raisins in a plum pudding. In the English and French and English and Spanish naval battles, the slaughter on the French or Spanish side nearly always far exceeded that on the English side. The French ships were fought with extreme gallantry, and the men frequently stood by their guns long after defeat was inevitable. They were defeated by superior seamanship and superior gunnery. Much of the success of the English was due to the skill with which their vessels were handled, and much to the rapidity with which they worked their guns; but a part must have been due also to their superior ballistics. The English followed the custom of reserving their fire until alongside the enemy, and

*Journal of the Royal United Service Institution, 1880.

then firing rapidly; but nothing can as well account for the far greater effect of the English fire as superior penetration that permitted such frightful slaughter.

The advent of shell guns made armor a necessity; but as protection increased the power of the gun increased, and the armor still being penetrable, the great size of the guns threatened the speedy destruction of the ship. Then the armor was taken from various parts of the ship, principally the ends, to protect the power of flotation by increased water-line protection. The motive power was placed below the water-line and thus well protected. The guns increased in size and power, and being of such great weight only a few could be carried. These were grouped together and well protected by armor. At this time not only were the guns' crews well protected, but they required few men in proportion to the size of the ship, and the places of the killed and wounded could be easily supplied; so the slaughter of the crew was not of vital importance. The fear of the loss of the vessel by sinking, growing with the size of the gun, was increased by the craze for rams and torpedoes. Great battleships were thought to be unwieldy and to be at the mercy of small rams and numerous torpedo-boats. Some common-sense and minute subdivision of the hull dissipated much of the fear of the former; electric lights, subdivision of the hull, but above all rapid-fire guns, stripped the latter of its excessive terrors. The Italians were the first to recognize that the gun was again in the ascendant, and that guns' crews must be well protected. They devoted a large portion of their armor to the protection of the battery, using subdivision of the hull, with water-excluding substances, to preserve the buoyancy of the vessel. Again the guns caused a change in the disposition of the armor, for it was found possible to use shell charged with high explosives which had an enormous shattering effect. While the heavy armor of turrets and barbettes protected the crew from direct assault, the effect of the high explosives was so great as to seriously threaten this huge structure from underneath. Not only did experiment show that they were all in danger from the force of explosion from below, but its great force threatened to blow out supports and let the structures down. About six inches of armor is considered sufficient at present to cause shells charged with high explosives to explode on the outside where they can do little or no damage.

The situation at present is this: the larger calibre of guns can penetrate, at close quarters, any armor that can be carried reasonably on a battle-ship, and but few guns of large calibre can be carried, and they require some minutes to load and fire. High explosives must be kept out and guns' crews must be protected, at least from the fire of the smaller rapid-fire and the machine guns. These circumstances have led to two principal types of armored vessels: the light armored vessels of high endurance, the real armored cruiser; and the heavy armored vessel of limited endurance, the battle-ship—both ships of the line. The finest developments of these types were outlined in the report of our Naval Policy Board, and are fairly exemplified, the first in the New York and the second in the Indiana. They are by all odds the finest vessels of their kind afloat to-day, and the present outlook is that they are types that will survive for many years, and the future improvements will be more in the line of perfection of detail than in change of design. The same parts of the vessel should be chosen as a target as indicated in the discussion of a combat between two vessels, and the admiral of a fleet should have it in his power to indicate to his ships upon what ship of the enemy they should concentrate their fire when the proper one is not evident from the situation.

A few vessels may be sunk and some may be set on fire by exploding shells; but in the battles of the future, as well as in those of the past, either before or after the motive power has suffered serious injury, the defeated ships will have retreated or surrendered because of the slaughter among the crew. It may be argued that it is more important to drive the enemy back with damaged ships than with diminished crews. But the manning of the fleets of any country will exhaust all or nearly all the trained men, and ships can be repaired, with reasonable facilities, in less time than men can be trained. Untrained men will be of but little use on modern men-of-war.

The condition of affairs has not changed the probable results so greatly as at first view would seem to be the case. Ships are much larger, and some carry very thick armor; but guns have kept pace also, and the relative value of protection and guns has not altered greatly. Increased calibre, better projectiles, improved ballistics, facility of train and rapidity in loading have kept the ratios from great changes, and the results of former

combats may still serve to elucidate modern problems. Well trained men, good marksmen, on inferior ships, may serve to win the day; and with equally well designed ships and weapons, the best trained men must conquer if the ships are handled by seamen.

Should the enemy be your superior in gun power, it will be necessary to try conclusions with the ram at the earliest opportunity, provided he is a good tactician and develops his gun fire, using his superiority to the best advantage. Should he be rash enough to attack with a narrow front, you can more than equalize his superiority in gun fire by maintaining a good formation; but as soon as his manœuvres cause you to run in parallel lines you must endeavor to close and charge him. The best formation in which to charge is fleet in line.

Having the advantage in numbers, it becomes a question how to make the best use of them. The advantage may be original or it may occur during the engagement, being caused by the enemy's vessels falling out of line, because of loss of men or because of damage to the motive power. Now, superiority in speed will tell greatly, for it becomes easy to double on end or flank vessels of the enemy, and such doubling up must prove fatal to the vessels attacked. With equal speeds it will require considerable skill to develop the full value of the superior fire; but by hanging a little off the quarter astern and a little off the bows ahead, some additional guns can be brought to bear from the extra ships when in column, as also by holding a little in advance on the flanks when in line. Another way to give the full effect to the additional numbers is to pass the enemy's fleet on an opposite course, both being in column, as in Fig. 7; but this the enemy can prevent easily. In case of ramming, the full value of the extra ships may be made to tell by forming them astern of the line and having them attack after the other ships have passed through.

With two fleets of equal speed it can hardly be expected that the formations will remain intact after much damage has been inflicted, for if one fleet commander finds his ships suffering more than those of his enemy, he will seek to close and gain in the mêlée, at close quarters or with the ram, what is denied him at longer ranges for want of skill with his guns. The admiral who has gained by gun fire will be loth to sacrifice his known advantage by allowing the enemy to close; but he will find it difficult

to avoid doing so, if both fleets are handled with equal skill. Again, accidents or damage will serve to disorganize the fleets, and here superior numbers can be used to advantage by filling up the gaps.

With two well handled fleets, the combat may be expected to be carried on with the ships in column and steering in nearly parallel directions, the interval gradually closing, until one threatening to charge and the other heading to meet it, the fleets come together. As they pass, some vessels may attempt to ram because of tempting opportunities, some to make up for loss of gun fire, some because they are threatened by their opposite numbers in the other fleet, and some because they believe in ramming at any and all times. Now good drill will tell. For a time the admiral will lose control of his fleet, but if his ships are well drilled and are instructed to haul out of the mêlée and form promptly, he may take a slower enemy at a disadvantage and concentrate his entire force on a portion of the enemy's unformed force. Superiority in numbers will now tell strongly. If it is sufficiently large to admit of forming a reserve, they can be sent against the enemy and strike him while in confusion. And if not held actually in reserve, they can form a second line; or if in the first line, some must be without opponents in the charge and be ready to return immediately to the fight.

The number of vessels that should constitute the line of a fleet is a mooted question. As is given in some tactical books, it is sixteen, eight forming a division and four a squadron. By some this is thought to be too large a number to form in one line. The distance being two cables, four hundred yards, the distance between the centers of the flank vessels would be six thousand yards, with sixteen vessels in line, so that the flank vessels would be too far away from the head of an attacking column to deliver an effective fire, and this difficulty would be increased with the fleet in echelon. The fleet might be manœuvred at a distance of one cable, and thus the distance apart of the flank vessels would be halved; but it is extremely doubtful whether the vessels could be manœuvred with safety in such close order during an action. When in column at half distance there would be less than a ship's length between the bow of one ship and the stern of the next ahead, and great confusion, if not disaster, would be probable if one of the vessels should be forced to stop suddenly.

Close order could be maintained readily in line, and might be an advantage when intending to charge, but it would prevent manœuvring with safety.

Eight battle-ships is a sufficient number to handle in one line, and the additional vessels should be handled separately as a semi-independent command. They could act in reserve or be used to strengthen either flank, or to extend the line should the enemy's ships overlap either flank. The fastest vessels should be held in reserve, so that they can be pushed around either flank when possible to double on a portion of the enemy's line.

Unless cruising near home ports, torpedo-boats will not be found forming a part of the fleet under ordinary circumstances. In long cruises they would serve to retard the fleet in its movements, and they would run very serious risks; but with a home fleet guarding the coasts, they would follow the fleet when not required to move too rapidly or too far for them. Then they could take refuge when the weather made it necessary. Whenever the weather permitted, and an action was probable near home, some, if not all, the harbor defense vessels would join the fleet, the proportion remaining in port depending upon circumstances.

It is well conceded that to open an attack, in daylight and in clear weather, with torpedo-boats is to invite their destruction without adequate returns. So the torpedo-boats of a fleet must remain under the shelter of the battle-ships, in a day attack, until a favorable opportunity arises for a surprise. They would be particularly useful in a charge, as coming around under the stern of one of their own ships, they could attack the bows of an enemy under the cover of the smoke that would be at its thickest at such a time, and after launching their torpedoes could seek the shelter of the same or another ship of their own fleet. Even if smokeless powder is used, the time of their exposure to fire would be very short, and the battle-ships would have to keep a very keen lookout for them.

One of the great difficulties in a mêlée will be to distinguish friend from foe, and the captain will require a cool head and a quick eye to be sure of his target when handling either battle-ship, cruiser or torpedo-boat, and the latter will be in danger frequently from friends as well as from enemies. They could carry distinguishing shapes in daytime. At night pre-arranged

flashes from the search-light, and in fog blasts from the whistle could be used when the officer commanding the boat was certain he was approaching a friend.

To be thoroughly effective the fleet will require fast cruisers to signal the vicinity of an enemy and to collect and disseminate information. Besides the vessels attached directly to the fleet and forming part of it, many cruisers will be needed to seek out the enemy and report his movements, and to drive back the scouts of an enemy and to prevent them from gaining similar information; those attached to the fleet being thrown out as the advance and flank guards of an army, while the latter are like the scouts of an army, striving to keep in touch with the enemy and cutting off his scouts. The scouts will operate independently of the movements of the fleet, being kept informed of the points at which the fleet is to be found. The admiral will make regular rendezvous for certain times, and use his despatch vessels to keep his scouts informed of any change in the programme. The cruisers of the fleet will be sent well out on the flanks and in advance, keeping directly within signal distance or having repeating ships between the fleet and their position. The position of the cruisers in front of the fleet must be at a greater distance than that of those on the flanks, as the distance between the fleets will close so much more rapidly if the enemy is approaching on the line of advance than if he appears on the flank. If armed merchant ships are used as auxiliaries, they will be more efficient as look-out vessels for the fleet than as scouts. In the latter service they would be badly handicapped for want of protection, and would fall an easy prey to a cruiser with her engines and boiler below the water-line and with a protective deck, even if she carried a more effective battery than a cruiser.

When operating near the home coasts the cruisers will be most useful in collecting information from the signal stations, sending orders for coal and other supplies and instructions to ships separated from the fleet. A system of telegraph lines, semaphore stations, pigeon stations and lookouts, to co-operate with the fleet, is an important and necessary adjunct to all naval operations conducted in home waters and form points to be attacked by cruisers when operating on an enemy's coast. The effective value of a naval force operating in its own waters will be increased greatly by proper shore stations and telegraphic facilities. Com-

binations can be made with greater certainty, supplies can be obtained more readily, and an efficient watch kept upon the movements of an enemy. Where lodgments are effected on an enemy's coast for supply stations to fleets masking other fleets or blockading or preparing to bombard ports, the telegraph cable is likely to come into play; and it seems probable that a telegraphic supply ship, with its corps of signalmen, will become as necessary a part of the equipment of an attacking fleet as the flying field telegraph is of an invading army.

A fleet must have attached to it ammunition and coal vessels, unless operating near a base from which supplies can be obtained readily. A reserve supply of ammunition will be found to be as imperatively necessary on the water as it is known to be on the land. Torpedo-catchers or torpedo-gunboats become important auxiliaries when operating where the enemy may be expected to have torpedo-boats.

It is important to have the vessels attached to a fleet, both those of the line and the auxiliaries, capable of maintaining about the same speed, otherwise at important moments the fleet may be tied down to some slow vessel, or to some light vessel, swift in smooth water but unable to steam rapidly in rough weather.

All great operations with fleets must be first directed to securing or maintaining the supremacy of the sea, afterwards utilizing this supremacy. For that purpose the first object of the attacking fleet will be to seek the enemy and endeavor to crush his fleet. Should the fleets be of equal force there will be but little difficulty under ordinary circumstances in bringing about an engagement. But should one fleet be inferior it may be forced to act on the defensive, when it will strive to avoid the stronger fleet, and yet to keep so near striking distance as to prevent its enemy from attempting any considerable operation while it was at large. The superior force, if in sufficient numbers, may strive to mask the inferior one with enough vessels for the purpose, leaving the remainder to undertake some other operation of importance. If not in sufficient numbers for this purpose it must endeavor to so operate as to force its opponent into risking an engagement. Upon the number of the cruisers and the manner in which they are handled will depend largely the success of either the attack or the defense. Should the defense be better served, the weaker force might be able to neutralize the effect of superior numbers.

But should the superior force have also the larger number of cruisers it should be able to mask its own movements whilst keeping constantly informed of those of its enemy.

The formations and evolutions necessary for battle are few and simple, and therefore a complicated code of signals will be unnecessary for manœuvring a fleet in action. The following code of signals has been arranged to show how few combinations and hoists are necessary, and is not worked out as an ideal code. Of course, shapes or positions of the semaphore arms could be readily substituted for the flags. The ruling idea has been to so arrange shape and color as to make the signal easily recognized. Each ship should repeat the signal when understood, and the haul-down should be the signal of execution.

The only formations needed are column and line, the echelon being formed from line or column, the vessels being drawn up on the line of bearing in one or the other of those formations, and then turning together 45° in the desired direction.

BATTLE SIGNALS.

1. Form column on leader. White flag.
2. " " " vessel indicated. White flag over distinguishing pennant.
3. Form line on leader. White pennant.
4. " " " vessel indicated. White pennant over distinguishing pennant.
5. Column right, 90° turn. Blue flag.
6. " " 67½° " " " one dip.
7. " " 45° " " " over white.
8. " " 22½° " " " " " one dip with lower flag.
9. " left, 90° " Red "
10. " " 67½° " " " one dip.
11. " " 45° " " " over white.
12. " " 22½° " " " " " one dip with lower flag.
13. Vessel right, 90° " Blue pennant.
14. " " 67½° " " " one dip.
15. " " 45° " " " over white.
16. " " 22½° " " " " " one dip with lower flag.
17. " left, 90° " Red "
18. " " 67½° " " " one dip.
19. " " 45° " " " over white.
20. " " 22½° " " " " " one dip with lower flag.
21. Open fire. Gun from flagship.
22. Concentrate fire on vessel indicated. Numeral (counting from right or leading vessel of enemy) over red and blue flags.
23. Charge. Red, white and blue flags.

Most of this essay was written before an account of the fight off the Yalu river was received in this country. Since then many reports of the fight have been published in the papers; but it is still impossible to make an accurate analysis of the evolutions performed. The Secretary of the Navy, in an article in "The North American Review" for November, has effectually demolished the outcry that by this fight battle-ships were proved to be failures. With the aid of the tables in his article, and by sifting out the probable truth from the many accounts, a fairly accurate idea may be formed of Admiral Ito's method of solving the tactical problem that confronted him on the 17th of September, 1894.

The following are the main features of the problem: The vessels of both fleets were of mixed types. The Chinese had five armored vessels. These five and one other had protection for their heavy guns. Of the four remaining, two were protected cruisers and two were gunboats. The Japanese had three armored vessels. These three, with three other vessels, had some gun protection. Of the five remaining, four were protected cruisers and one a gunboat. The displacement of the Chinese vessels ran from 7430 to 1350, aggregating 32,915 tons; and the Japanese ran from 4277 to 614, aggregating 36,462 tons. The highest nominal speed of the Chinese was 18.5, and the lowest 10.5 knots. Of the Japanese the highest was 23 and the lowest was 13 knots. The Chinese had eight 4.7″ guns, seventeen 6″ and twenty-five larger guns, and the Japanese had fifty-nine 47″ guns, twenty-six 6″ guns and seventeen of larger calibre. At least four of the Chinese and five of the Japanese had no place in a line of battle under ordinary circumstances. There were besides the vessels mentioned above, several Chinese gunboats and torpedo-boats that did not enter into the fight.

The Chinese were probably drawn up in double echelon, apex to the front, with the two battle-ships of 7430 tons each in the center. If they were in line or double column, the formation was so irregular as to give the appearance of double echelon.

Admiral Ito knew that the extreme speed of his enemy was ten and one-half knots, while his own extreme speed was thirteen knots while in formation, with the probabilities of at least one knot less. That the two battle-ships were his most formidable antagonists, as they were larger and better protected than any

of his vessels, and could make over fifteen knots. That while the Chinese had a few more heavy guns than his vessels, they had only a few light guns and very few rapid-fire guns; whereas all the vessels of his fleet were well supplied with light guns and carried fifty-nine rapid-fire guns. He saw that with his great weight of fire properly developed he might fairly expect to crush down the fire of his enemy and damage his guns or drive his crews from them. That until the enemy's fire slackened, when he could draw closer, he could greatly lessen the danger from the slow-firing guns of the Chinese by keeping his vessels moving rapidly at a rather long range. He determined therefore to cross the line of direction of his enemy, with his fleet in column (Fig. 9), with broadsides bearing, concentrating his fire on the two battle-ships at the apex, and thus to damage them so as to prevent them from any future attempt to ram with any reasonable hopes of success. He chose the distance of about 4000 yards, so that his fleet would be able to draw well clear should the Chinese attempt to charge. He then, after passing the battle-ships and finding that they made no attempt to charge, changed direction, and drew his line past the flank of the Chinese, thus concentrating all his fleet on one or two of his enemy's vessels. After this the accounts are confusing. Admiral Ito had won the first move, and his enemy were unable to recover the advantage he gained. His fleet evidently circled around the flanks and rear of the Chinese in one or two divisions. The Chinese, while fighting bravely, were being slaughtered so rapidly as to be unable to do anything but keep up a slow fire with the heavily protected guns that remained uninjured. The Chinese drew off, followed at a distance by the Japanese. Four of the Chinese ships were sunk and one of the battle-ships was injured. Some reports say that the Ting-yuen, a battle-ship, was down by the head when the fight was over, and all agree that both battle-ships were on fire forward, which will account for their not attempting to ram. But the accounts of the killed and wounded are still more significant. Over one thousand Chinese were killed or wounded out of about four thousand men, while the Japanese lost less than three hundred, with about the same number of men.

The reports differ as to why the Japanese failed to push close after the Chinese fleet. Some say they feared the attack of the torpedo-boats after nightfall, and others that the Chinese were lost

in the darkness; but it seems highly probable that after such a long engagement Admiral Ito found himself short of ammunition, and, excellent tactician that he is, he recognized the fact that the Chinese fleet was thoroughly defeated and that the strength of his ships did not warrant his attempting to destroy it by ramming. It would seem as if the only battle fought by fleets with modern weapons fully bears out the deductions drawn from the history of former battles, and that a decisive victory is to be gained by concentration of fire and concentration of ships, thus driving an enemy from his guns, rendering it impossible for him to manœuvre, and disabling his fleet by the slaughter of his men.

It is known now that the problem was solved correctly, and that Japan has been well repaid for her frequent fleet manœuvres and careful organization, and that in Admiral Ito Japan has an admiral who is both a thorough seaman and a brilliant tactician. Without an accurate knowledge of the actual injuries suffered by the fleets engaged, yet the completeness of the victory is shown by the results and illustrated by the fall of Port Arthur. The results of the victory would not have been greater had Admiral Ito seized or destroyed all the opposing fleet. He gained the command of the sea, and the fight off the Yalu river must take rank as one of the decisive battles of history.

It is evident, when considering tactical problems, that the details which are of importance are numerous, but the tactical evolutions that are required in battle are few. Yet few and simple as they appear, they are necessary and must be performed correctly. A fleet engagement may be compared to a game of chess, where various openings are possible and they admit of close study, and the correct replies may be predicted for each move. Yet a brilliant chess player, unacquainted with the openings, might be beaten by one less skillful, who, knowing them, might gain a decided advantage in the outset of the game. So with the tactician, only the early part of an engagement can be studied clearly beforehand and the correct evolutions predicted; but it is most important to open correctly, and is so easy to lose the advantage early in the combat that the best tactician may have an uphill fight if he neglect his opportunities in the outset.

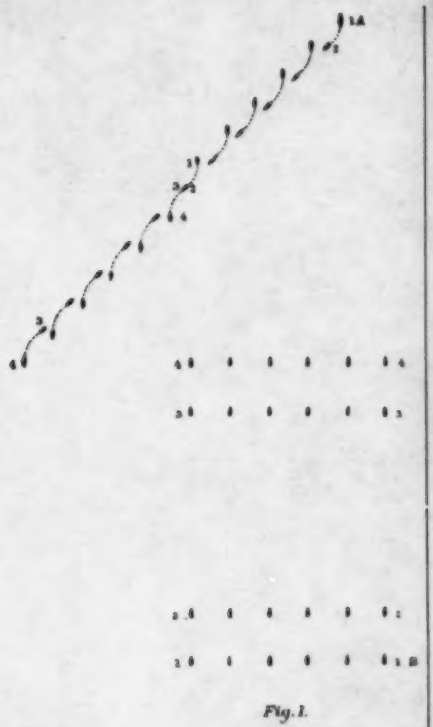
Above all, the tactician must be a seaman. Strategy is a science and is capable of being reduced to fairly exact rules. It is possible to carry on its study in the closet with but little sea

experience. Tactics is an art, it has only a few rules capable of many applications. Study alone will not make a good tactician; he must have a wide experience with sea-going ships under service conditions, and he must have that faculty pre-eminent in all true seamen, of quick decision, with ready observation. The tactical details so necessary to the proper conduct of a fight are only learned by careful study, after intimate knowledge of a vessel of war. Of what use is a cruiser as a scout for the fleet unless the captain is a practical seaman—one accustomed to the appearance of the various types of ships at sea? When he sees his opponent he must be able to gauge his strength and tell in what points he is superior and in what inferior to his enemy, so that he may endeavor to fight in such a manner as to develop his superior points and nullify those of his enemy. When the captain of a scout sights the enemy, if he be an experienced seaman he will be able to give definite information to his admiral, and will obtain his information more readily and run fewer risks than one who has not had his advantages.

An admiral being a seaman of experience, will grasp the indications shown by the enemy and meet his movements at once. He will select the enemy's weak point and concentrate his force upon it, and he will guard his own weak points and prevent concentration of the enemy. He will recognize when his gun fire is crushing the enemy or when his vessels are being worsted by the superior fire of the enemy. Thus he will be able to decide when to avoid a charge so as to retain his advantage, and when to charge so as to destroy his enemy's advantage, or so as to turn his first success into a complete victory.

The strategic problem may be carefully and correctly worked out, and all tactical details attended to with skill, the fleet brought in the presence of the enemy, thoroughly prepared for the fight, at the right time and in the proper place, and then, without a commander who is both a seaman and a tactician, all the finely wrought combinations fail.

There are other tactical problems, such as the tactics of the attack or of the defense of a harbor, that the limits of this essay will not permit being discussed. Many tactical details have been omitted or merely touched upon for the same reason. But the essay will have served its purpose if the writer has been able to make clear the importance of the art, its solid foundation in the history of the past and its close alliance with the art of seamanship.



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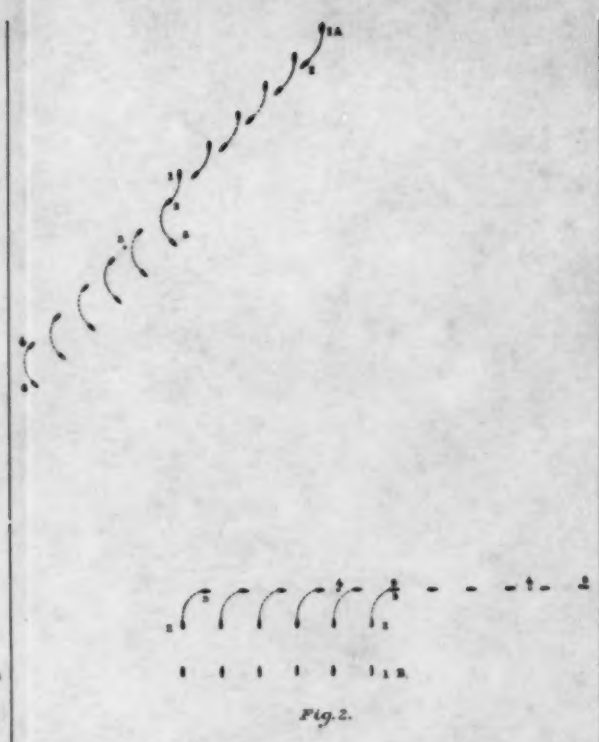

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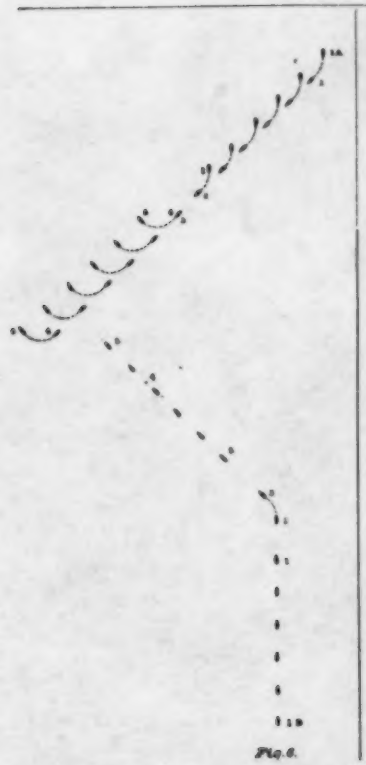
Fig. 3.



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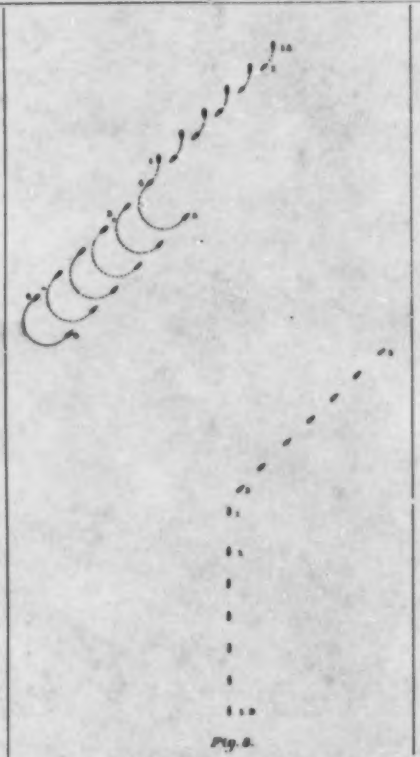

Fig. 8.

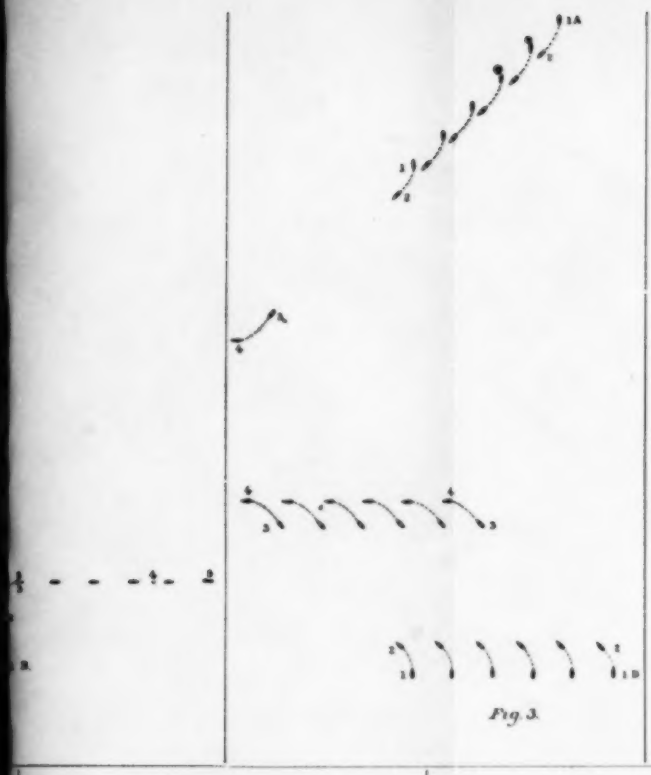

Fig. 3.

Fig. 4

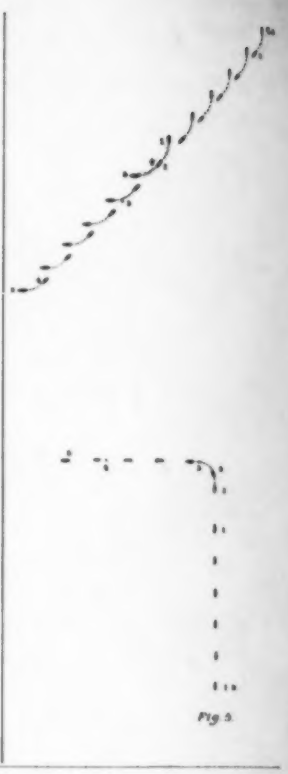

Fig. 5.

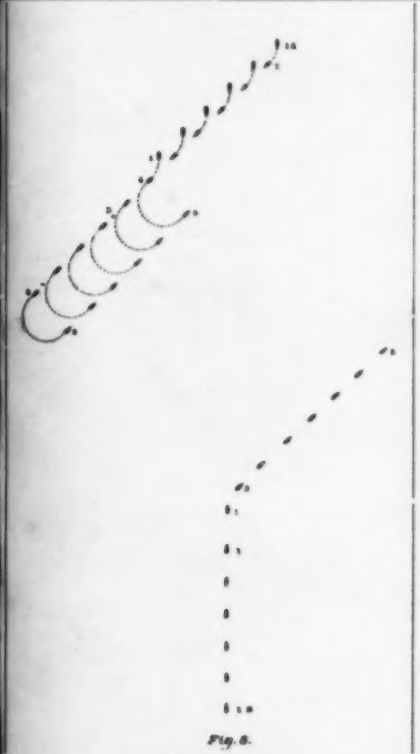

Fig. 6.

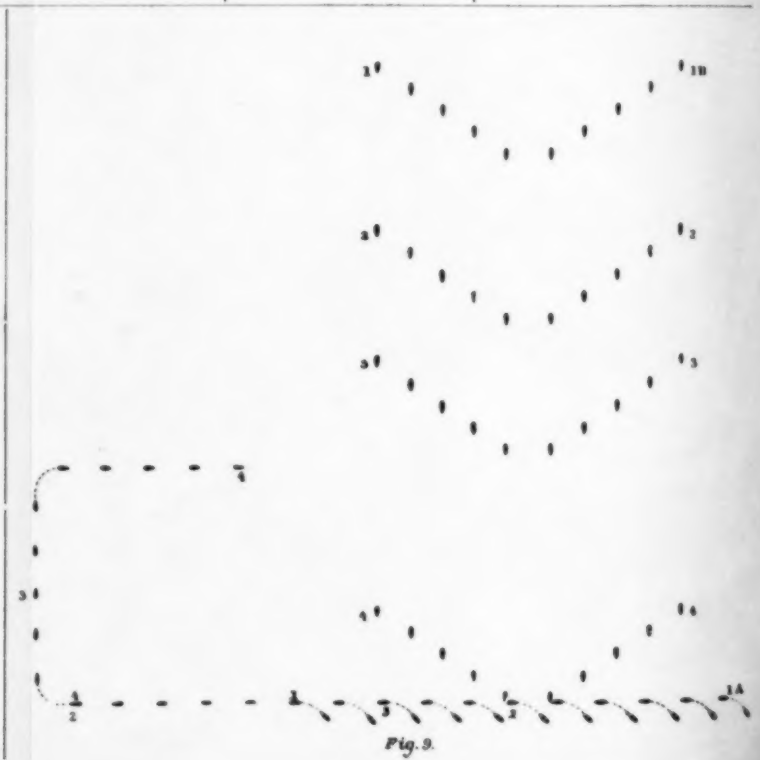

Fig. 9.

DISCUSSION.

Commander C. F. GOODRICH, U. S. N.—This essay is an admirable example of what our Institute is capable of bringing out, and I am in agreement with the Board of Control that it well merits the distinction awarded it. There are many points wherein a difference of opinion may lie, but as a whole I think the members have cause for self-congratulation on its publication.

I confess to a wish that the elements in the fleet had been discussed at greater length, for they are yet ill-defined in my own mind. I had especially looked for light on the subject of the armored cruiser, a type whose exact place and functions are not clear to me. I grant its excellent qualities and I speak of the New York with just pride; but in time of war what shall be her rôle? I can understand the battle-ship and I can understand the cruiser. Their prototypes were the 74-gun ship and the frigate. The gradual settling down to one standard unit in, and the elimination of the frigate from, the line of battle is well shown by Admiral Colomb. What new necessity has arisen for the bewildering heterogeneity of the modern navies of the world? The writer carries hope to many hearts in recording "a tendency to settle down to fewer types of vessels." Yet without this tendency crystallized into rigid practice the handling of his supposed fleets will be difficult beyond measure. What *can* be done with a squadron of vessels all or nearly all of which vary in size, speed and tactical qualities?

I have limited my remarks to the point on which I need most enlightenment and which, it appears to me, might have been longer dwelt upon profitably. As a whole, this essay, written in a capable and conservative manner, seems exceptionally free from attack.

Lieutenant-Commander SEATON SCHROEDER, U. S. N.—The prize essay of this year is a comprehensive and masterly discussion of the elements necessary to naval victory. While the commander of a fleet should not have his mind burdened with details, distracting in more senses than one, it is to be observed that the successful commander is he who appreciates the value of details and who can, without direct personal supervision, ensure the perfection of his fleet in these minor essentials. A consideration, therefore, of the details involved in arming and preparing a ship for action seems eminently appropriate in a paper such as the one under discussion.

A most important question is raised in the early part of the essay as to the kind of gun best adapted for cruisers, and the suggestion that for them it would seem better to decrease the length and increase the caliber is both interesting and wise. Until comparatively recently there were many advocates of the principle of mounting a few large heavy guns in small vessels as opposed to a greater number of smaller guns. These advocates could not stand up long before the inexorable logic of facts, and the same revulsion that is always created in such cases,

apparently, carried popular opinion rather too far the other way, being helped on by the extension of the application of rapid-fire mechanism to 4-inch and 5-inch guns. It is strange that in the proposal to put large guns in unarmored vessels it has always seemed to be taken for granted that they should be heavy and high-powered. Why not keep a large caliber as proposed, but decrease the weight and power? A 9-inch gun weighing 12,000 pounds, or about the same as a H. P. 6-inch, would throw a most destructive shell with an I. V. ample for all needs of a cruiser. It would not go through heavy armor; but cruisers are not intended to fight heavily armored vessels; and even if caught by one such, a vast amount of damage could be done, and the explosion of such heavy bursters might well give a chance to escape before being totally wrecked. The higher trajectory would make long range firing more dependent upon an accurate ascertainment of the range than if the battery were H. P. 6-inch; but if the vessel armed as proposed keeps pointed at full speed for the enemy it will be almost impossible for the latter to prevent the action taking place at 1500 yards or less. Of course heavy, long-range guns should be installed for end-on fire in either direction, and the broadside 9-inch guns would be fitted to use metallic case ammunition to secure rapidity of fire. Other things being equal, in a duel at a range not exceeding 1500 yards, one ship having a broadside battery of H. P. 6-inch guns and the other the same number and weight of low-powered 9-inch, there should be no doubt as to the result. As expressed by the essayist, "The cruiser throwing the larger shell would be more powerful than the one armed as at present."

In the study of the individual ship, means of internal communication under varying phases of disablement are of primary importance, and the solution of the problem comprises not only the best and most ample independent lines of voice tubes and telephones, but even still more necessarily the installation of guns, torpedoes, steering engines, dynamo rooms, magazines, etc., in such wise as to reduce to a minimum the number of such necessary lines. Every instance of the power to give an order *viva voce*, instead of by tube or messenger, is a distinct gain in efficiency. For all such questions bearing upon the efficient handling of the battery (which is the one object for which naval vessels are built) it would be well if the Chicago could be paraded as an object-lesson before the navy.

The 7th question, regarding the provision for making signals, is well answered by the essayist, and too much weight cannot be attached to his statement that "protection must be provided for the signalmen." In all vessels a certain amount of signaling is likely, but in a flag-ship there will necessarily be much more and it will be more vital. And yet when we hear that such and such a vessel is to be changed into a flag-ship the alterations do not generally go much further than to cut the captain's quarters in two so that he and the admiral shall have separate places to eat and sleep. I do not remember hearing of any of our vessels thus transformed being provided with a military shelter for the commander-in-chief nor for the signal officers or men. Yet what is

more important? Machine guns, as at present constituted, would annihilate all these people at a considerable range. There should be a tower for them, impervious to secondary battery fire, either immediately over or in intimate communication with that of the captain. This will add weight, of course, and the weight will be high up, but it is an absolute necessity; if that be recognized it will remain to be decided which type of ship is best for the admiral to be in, to fit up no more of those than necessary and to make the towers as small as compatible with convenience. It would seem that the necessarily restricted size of this tower constitutes in itself a valid argument against the adoption of a signal code requiring as many flags as does a letters code, which is sometimes advocated in place of one using numerals.

While I agree that there is danger in carrying live torpedoes in above-water tubes in action, I think I would have them prepared if close action appeared probable, for the chances of the little 35-grain fuze being hit are small, and the charge itself if hit should not detonate. The air flask is a source of danger, of course, but there are torpedoes that have other means of propulsion. I am referring to broadside tubes. I cannot imagine any one leaving a torpedo in a bow tube of a ship.

The hint regarding the escape of gas from explosions between decks brings us right against the time-honored custom of battening down all hatches that can be spared. What object can be gained by that practice nowadays, or what harm will result from leaving them all open, is hard to see. The exploit of the gallant topman dropping a grenade from the Bon Homme Richard's yard-arm down the hatch of the Serapis and killing and wounding sixty-odd men will not be repeated in these days.

The recommendations, in answer to the 13th question, that there should be several protected stations from which the captain could fight his ship, and that the conning tower should be of easy access and communication from the deck, will undoubtedly find a universally favorable echo. Before the importance of the matter was realized, instances were known of the route from the tower to the deck being made long and circuitous and of there being no way of communicating from the deck with the men at the conn. Such a mess simply invites disaster. There is hardly anything more important than perfect freedom of movement for the captain; he should be able to leave the tower and gain the deck at any instant, handle his ship perfectly from outside and jump in again at a moment's notice. All such terrible mistakes will probably be corrected and certainly will not be repeated; professional voices should be raised in protest, if necessary, against such a handicap.

The problem of ramming or being rammed is indeed not one of simple diagrammatic solution, and the principals in a duel will do well to remember that distances will not be as accurately estimated as on the drill ground, and furthermore that the curves described will not always be the same; difference in trim, relative force and direction of wind and sea, difference in the relative speeds of wing screws, variations in the times required to stop or reverse the inner screw and, most of all,

the uncertainty as to what the other ship will do,—these all combine to take it out of the category of an exact science. A quick eye and hand skilled in sea-craft, and a cool brain comfortably stocked with sound judgment and practical sea experience, are the instruments with which one may save that vital "half-length."

The discussion of the formations in which to fight a fleet carries with it doubled weight and interest as coming from an officer known to have given so much thought to the subject. A salient feature of the position taken is approval of the echelon formation; and the fact, as stated, that it is a difficult one to double upon certainly imbues it with important tactical strength. It is difficult to work out by diagrams the innumerable problems arising from the many bearings on which the enemy may appear. The essayist has fully considered the cases in which he bears ahead from your echelon, and, if desired, that situation could generally be brought about. With him bearing at right angles to your line-of-bearing, the echelon formation will continue to present certain advantages, prominent among which is that of bringing to bear the greatest number of guns while presenting the smallest target, and that I take to be a cardinal principle. It also places the water-line and battery armor at an angle with the line of fire. It is assumed, of course, that all the broadside guns can be trained well forward and aft of the 4-point bearings; no vessel not thus arranged has a proper right in the line of battle; vessels with turrets placed diagonally carry the stigma of vital defect in their inability to concentrate the fire from both turrets on either bow and quarter.

Being in echelon, on a line-of-bearing perpendicular to the direction of the enemy, if he advances in line you will gain sea towards his flank, and, to prevent concentration of your fire on that flank, he may form column, turning in that direction and bring his broadside to bear. You will now be giving him gun for gun, while maintaining the most favorable angle of presentment. If some of your battery should become disabled a simultaneous turn of eight points towards him would put you in echelon with the other flank forward and a fresh battery in action, and you would draw toward his rear. If the relative marksmanship or gunnery power of the two fleets be such that these conditions are favorable to you, the condition should be maintained as long as possible, being prolonged possibly by reducing speed or possibly, if not too near, by changing course again eight or sixteen points and steering in retreat in echelon. The propriety of manœuvring in this way will depend a good deal upon the distance of the enemy. To change formation in his face might easily be a fatal error, and even changing front should be well considered; moreover, the time taken up would be practically lost to the guns, as the snap shots taken while turning with full helm would probably not be very effective.

A valid reproach to the echelon formation is that it is not elastic and that before entering another formation the squadron has to form line or column. Another disadvantage is that the distance between vessels is sometimes thrown out by entering it and sometimes on leaving it.

But if these peculiarities are kept in mind and looked out for, great advantages may attend its employment. While manœuvring as suggested above, if the enemy makes up his mind to close you cannot well stop it; but up to the last safe moment you will have the advantage by keeping in echelon, and when the shock of the charge comes you should be in better shape than he.

I agree with the essayist that sixteen modern vessels is an unwieldy number for the line of battle. If in line or column, even with the commander-in-chief in the center, there could be little or no signaling, and, in line particularly, bearing and distance could not be well kept. While there should be as little signaling as possible after the action has become imminent, some will be necessary if only to indicate that a previously arranged 1st, 2d or 3d plan of action is to be followed; and smoke from guns and funnels will make that difficult enough without the additional perplexity of distance.

Half-distance is too close for battle. I have seen our own and a certain foreign squadron at drill at half-distance; and Admiral Walker's full squadron of eight going through Hellgate at half-distance, 10 knots, was a handsome sight and a fine object-lesson. But on all such occasions there is no shooting going on and no smoke, and, moreover, all the best compensated compasses are in place and various more or less useful implements for verifying bearing and distance are conveniently installed. In action there will be little more than the one, possibly sluggish, compass in the tower, a more or less restricted field of view, an undoubtedly greater tension on the nerves, smoke, roar, confusion, the distraction of looking out for torpedo-boats, anxiety regarding the signals, possibility of loss of control for a short but vital space of time (through disablement of steering gear or steering men), etc., etc. In line, which in some respects is safer than column, although more difficult, that thing about compasses is most serious. The echelon formation comes again to the front in this connection; the principal danger would be that when enveloped in smoke one vessel might forge ahead into the line of fire of her leader, or drop astern and endanger her follower in the same way; but that would not be as serious as the possibility of ramming the leader in column or coming together in line.

Eight, therefore, appears to be about as many vessels as should ordinarily be in one line or column. If more are present a compound formation could be adopted and the second squadron would have to be more or less independent, as suggested by the essayist; that is to say, independent of all except general instructions to protect either menaced flank, concentrate on some one part of the enemy, etc. The first squadron being at "distance" apart, the other, whether the formation of each be line or column or echelon, could keep close enough on the off-side to form an effective indented line, column or echelon; that is to say, to have their guns bearing through the intervals. In case of a charge through, should the enemy receive the attack in column, the rear line should range up on this side of him with the same helm as the van and thus double on him in position; should he receive it in line, the rear

ships should get astern of their leaders in the van line by the time the fleets got together, and possibly by previous signal try to ram the enemy's ships as they come through. Torpedo boats and their antidote, the "hunters," would have an influence in individual cases in modifying the decision as to what precise course to pursue; but the relative positions of squadrons just indicated appear to be the best calculated to develop to the utmost the gun power of the whole fleet, torpedo-boats or no torpedo-boats.

The closing paragraph of the essay is the enunciation of a sound maxim. The naval administration which fully realizes the importance of the art of naval tactics and its close alliance with the art of seamanship will, in war, find itself well repaid for expenses incurred in the preparation of officers and men. A seaman admiral is needed to handle a fleet, a seaman captain to handle the ship and a seaman gunner to handle the gun. In a broadened sense, "the man behind the gun" will decide the day.

Lieutenant J. F. MEIGS, U. S. N.—I have read Lieutenant-Commander Wainwright's article on "Tactical Problems in Naval Warfare" and have been much interested in it. Mr. Wainwright has given us a very good historical resumé of the progress of change in naval equipment and warfare. I say change, and not improvement, advisedly, for I am by no means sure that all the changes which we have witnessed in the last 30 years have been improvements. The people occupied in developing guns and torpedoes, steam engines and ships have run away with the naval officers and have produced wonderful results, but in many cases have failed to secure a proper balance of various elements. We have far too much complication in almost all respects. In my view the whole kernel of the gun question now is to be found in its breech mechanism and gas check and in the size of its bore. In other words, all other details of the modern gun are so well worked out and so nearly similar as to be devoid of interest. I question whether present guns can be operated rapidly, because of difficulties in opening the breech, and I also question whether the present strife for higher velocities, which means necessarily long guns and large powder chambers, is well advised. If ships will engage at distances less than 1000 yards from each other, as I believe will be the case, it is of small consequence what a gun will do outside of that range; and if the whole of the trajectory of the gun for 1000 yards is dangerous space, then the two elements which give flatness of trajectory—high velocity and what is called sectional density or length of shot—are sufficiently developed.

It appears to me that the respect in which needed advance has been most lost sight of is in slowness in ammunition supply. The means of supplying ammunition are not materially better than they were 50 years ago and are perhaps absolutely slower. Yet we have added numerous devices which should enable guns to be fired at much greater speed than was the case 50 years ago. My own view is that the general estimate put upon this increased celerity of fire is far too high; but

there is an increased celerity of fire without a parallel increase in the facility of supplying ammunition.

Very interesting are the tactical questions of the proportion of hits which will be obtained at given ranges and the closely allied question of the determination of range. Inside of the danger space the determination of the range is unnecessary, and this is the principal reason for high velocity in projectiles. The proportion of hits which we will get to-day is not, I think, materially greater than what would have been got with the old guns, if both be operated within their danger spaces. The new gun is a more accurate instrument than the old one; but the gun is so much more accurate than the men who use it that the accuracy of the man and gun taken together has not materially changed. Nor are our methods for determining range, which becomes of consequence outside of the danger spaces, better than they were formerly. The effect and result of this is that it will be of no value to fire guns outside of their danger spaces. In other words, ships must, as they always have done, fight within the danger spaces, and though we should no doubt have the best range-finding apparatus which can be had, still because guns cannot hit often beyond their danger spaces, and because the best range-finding apparatus is inaccurate and clumsy, we must recognize the fact that guns will not be used much where range-finding is necessary. If all these things be true, numerous important tactical results follow. The range, which is the element of naval combat about which we are most uncertain, becomes fixed.

The most interesting question in gun tactics is concerned with the fixing of the caliber of a gun. Should we have in each battle-ship 13-inch guns, of 30 calibers length, weighing 60 tons, and throwing projectiles of 1100 pounds weight, or should we have 16-inch guns, of the same weight, of less length, and projectiles of the same length but necessarily of greater weight, or guns of 13-inch bore but of lighter weight than the present 13-inch? Such is one of the questions now pressing for decision. The whole world, following this country, has within the last three years adopted face-hardened armor. Such armor can be destroyed by weight of shot. It can be destroyed also, it is true, by comparatively light shot moving at high velocities; but having in view the introduction of face-hardened armor, are guns of the present right, or should they become shorter and have larger bores, heavier projectiles and lower velocities? But though the velocities become less, yet if these velocities, having in consideration the increased weight of shot, are sufficient to retain unchanged the form of the trajectory of the shot in the first 1000 yards of its flight, then for the purpose of hitting or for purposes of war the use of the larger bore gun with the same weight will cause no loss whatever. It will cause many gains which it is not necessary here to enumerate and will, as I say, cause no loss. Again, the use of larger bores and lower "power," to use the term generally employed, would carry us back to the use of smaller and lighter charges. In other words, would enable us to increase the ammunition-supply of ships, which has now, as we all know, reached an extremely low point. We

used in former days, in direct fire, charges as low as 1-9th or 1-10th of the weight of the projectile. This would result, as compared with the present practice of loading guns, in ships carrying five times as many charges as now without alteration of their magazines. Even if the charges were reduced to ¼ or ⅓ a material gain would be effected, or we should gain all that we hope to gain in ammunition supply by using smokeless powder.

Such questions could be multiplied indefinitely and are of the highest interest and importance. And if these be not solved, and solved correctly by naval officers, they will remain without solution. I therefore hope that Mr. Wainwright's paper may meet with a full discussion and may lead to the elucidation of the numerous points dealt with. I have no criticisms to make as such on the views which he expresses. I have no doubts in my own mind that the gun is and will remain, as he appears to admit, the principal weapon in naval warfare. Ships should, however, not be without rams and the mobility which will enable them to use these. Of the torpedo I do not feel so sure. It is extremely complicated, and it appears to me that its use anywhere but well below the water-line is most perilous.

In regard to armor: As ships stand to-day ordinary unarmored cruisers with the guns of their main batteries can penetrate their twins anywhere, even if their tops are below the horizon; that is, at ranges enormously greater than those at which they can hope to hit. One hundred years ago frigates could not penetrate their likes outside of about 1000 yards. Similarly to-day battle-ships without face-hardened armor can usually penetrate the heaviest armor of ships of the same class at about 2000 yards range, that is, at ranges where they can rarely hit; whereas in former times battle-ships could penetrate their likes at ranges of about 1000 yards or just beyond the then existing dangerous space. And unless the men who are to fight the ships to-day have steadier nerves than those of former times, the strain thrown upon them is perhaps injudicious.

Prof. P. R. ALGER, U. S. N.—Referring to Mr. Clowes' first question and the lecturer's answer, I think it should be pointed out that we pay too little attention to designing the internal fittings of our ships of war for war purposes. Ships should be cleared for action, as far as practicable, by their designers. We cut our decks up too much with unnecessary bulkheads; build too many staterooms and offices; have too much furniture and too many movable ladders, stanchions and canopies. Every bulkhead not actually needed for structural purposes should be removed from the gun decks, and all wooden sheathing, ladders and hatch combings should be abolished, so that the fighting decks are always as clear, fore and aft, as they can be.

As regards the lecturer's idea of designating various parts of an enemy's ship to be attacked by the different classes of guns, it needs but a glance at the accompanying sketch to show the impracticability of such a scheme. This sketch, if held fifteen inches from the eye, rep-

resents the Indiana as she would appear at 2000 yards range, only with much sharper outlines than would be the case in reality. To attain the best results *all* guns should be pointed at the middle of the enemy's ship except at *very* close range.

Lieutenant A. P. NIBLACK, U. S. N.—The questions dealt with by Lieutenant-Commander Wainwright are so much to the point that whether or not his solutions are entirely satisfactory is of less importance than that a great body of progressive officers, line and staff, should be reminded that there are such questions in the naval profession. Unfortunately we need these reminders, for they are not such live issues with us as with some other navies. To be sure, our ships are noted for their smart appearance, their double bottoms are inspected with the greatest frequency, and the numerous returns and blank forms are, in the main, very creditably filled out. Everywhere the new navy makes a good impression, and in the cuts and pictures in the newspapers and periodicals the new ships lose none of their impressiveness. But in the matter of systematic target practice, of turning circles, fleet manœuvres, torpedo drill, the school of the ship, the school of the section and the things which count for battle efficiency, our experience as a body of officers is remarkably limited. This is, however, not the fault of naval authority. Our few cruisers have been entirely absorbed in police duty for the State Department and in watching various political upheavals in remote parts of the world. We can only hope for a squadron of evolution when we get battle-ships which cannot be sent off on telegraphic notice to Kamschatka or Zanzibar, and only hope for good work out of the squadron when it goes off to some secluded body of water, for two or three months at a time, to escape the distractions from the inevitable visitors. Two ships fervently employed in the school of the ship and the school of the section for two months can give more valuable experience to the people on board than can be gained by a conventional three years cruise on any station as now conducted.

Our principal data for solving tactical problems we must glean from foreign periodicals, for our familiarity as workmen with our own tools is largely theoretical.

The following are some of the points very well worth noting in the essay under consideration:

"It is evident, when considering tactical problems, that the details which are of importance are numerous, but the tactical evolutions that are required in battle are few." Our Fleet Drill Book needs revision along these lines.

"The object of the manœuvres will be to have as many guns as possible bearing on the enemy, to keep within fair range, to avoid unneces-

sary waste of ammunition, and to allow him to use as few of his guns as possible." If it were added also, "To keep the weather gauge," then this would fairly state the problem of battle tactics.

"When the captain is on deck the executive should be in the conning tower, and if the captain is in the conning tower the executive should be on deck under some protection. . . . There should be several protected stations, at least one on each bow, from which the captain could fight his ship (but connected with the conning tower as to signals). . . . When piloting is necessary the navigator must be at or near the wheel to conn the ship and keep her from running aground, as the captain would probably need all his faculties to fight his ship properly. . . . The senior watch (ordnance officer) should not be called from his duties, unless required to take the position of the executive.

"The tendency is to settle down to fewer types of vessels. . . . The finest development of these types (armored cruisers and battle-ships) . . . are exemplified, the first in the New York and the second in the Indiana. They are by all odds the finest vessels of their kind afloat to-day, and the present outlook is that they are types that will survive for many years, and the future improvements will be more in the line of perfection of detail than in change of design."

The belted or armored cruisers "are fit, usually, to take their place in the line of battle, and are battle-ships of great coal endurance with comparatively light armor." This is rather heretical, but certainly the Brooklyn need ask no odds in the line of battle. Unless we get more ships than are planned we will not have any line of battle.

As regards what the essayist says of "Clearing Ship for Action," I think a clearer view may be had of the question by considering that its object is: 1st, removing obstructions from the working of the battery inboard and clearing the arc of each gun's fire outboard; 2d, removing splinter and missile-producing objects from the vicinity of each gun and chain of ammunition supply; 3d, taking all precautions to prevent wreckage from fouling the screws; and, 4th, improvising protection to exposed men (signalmen, sharpshooters and helmsmen), to torpedoes and their gear, and supplementing, as far as possible, the ship's protection to its vital parts. In time of war the ship would always be as nearly ready as practicable, and on going into action as much would be done as possible in the time allowed. The unbending of chains is of doubtful expediency. If, in ramming, they should drop aboard the enemy, by veering and letting go the bitter end you might be able to present him with that much additional weight to help him down. The ability to let go anchors on soundings to spring a battery, if disabled in engines; or with a ship dangerously down by the head from being pierced forward, the ability to let go anchors and chains quickly to relieve her; or in case of an anchor being knocked off the bows from any cause the chain would hold it,—these considerations give us the choice of bending or unbending according to the chances. With a disabled crew and a ship well battered up there would be enough work to do after or during an engagement to make bending chains quite an

unwelcome task. The danger from having chains bent is reduced to a very small margin if the stoppers and bitter ends are accessible for cutting or slipping quickly.

The question of steering the ship by the bridge wheel or that in the conning tower is one worth considering. As long as the danger is not too great the bridge offers every advantage, but the helmsmen should be protected by hammocks. The protection to signalmen is almost impossible except such as hammocks afford.

The question of the danger of the war-heads of the Howell or Whitehead torpedoes being detonated by a chance shot might be settled within all reasonable limits and very inexpensively at the ordnance proving-grounds by a series of experiments on models. There is no question as to the danger from the Whitehead reservoir being pierced, but I think the other danger is seriously exaggerated. Using underwater tubes reduces this to a minimum, but these have certain disadvantages.

In the question of interior communication we strike great difficulties. Speaking or voice-tubes are a failure and they weigh inordinately. The telephone is the best substitute, because any danger from interrupted communication owing to the wires being cut in action can be overcome by running wires over all as in the army field telephone service. This device consists of a reel of wire and two small telephones. For use on shore the wire is several miles long, but on board ship a number of sets of telephones with shorter wire should be kept in the conning tower in action to run to parts of the ship to where the regular communication has been cut off. This is by far the best solution of the problem.

One excellent means of getting the range of an enemy, if the height of his masts is known, is by means of the Fiske Stadimeter. Each divisional officer should have one and determine his own distance for himself when they fail to inform him from the bridge or conning tower. If the heights of the masts are not known they can be gotten approximately as follows: Get accurately the distance of the ship by means of a range-finder; set the stadimeter at that distance and bring the images in contact by means of the tangent screw. The height can be read off the scale. Two or three approximations will give it pretty nearly.

Signaling in battle offers many difficulties. In time of peace it is not an easy matter to communicate under certain circumstances. At night we have ample means of communicating, but in the daytime flags are very unsatisfactory. The smoke of battle at times corresponds to the conditions of a fog. In our ships steam whistles are, as a rule, badly placed for signaling. The best solution of the signaling question is to put large military armored masts in all vessels that can stand them and use them for signal towers. The base of the mast should, in the flag-ship, be an armored compartment for the admiral and his staff. Some of the signalmen would be in the tops. A steam pipe should be run up the mast to a whistle for signaling purposes in the top. A cone reflector should be used with it to throw the sound in any special direction. Certain battle signals in the daytime would be made with Very's

stars and rockets. If the halliards are shot away battle signals with flags could be made from the tops by bending the desired flag (if only a one-flag signal) on a staff and waving it from the top till answered. A jack-staff in the top would enable two-flag hoists to be made.

The essayist gives a battle code of signals which is only intended "to show how few combinations and hoists are necessary, and is not worked out as an ideal code. . . . The ruling idea has been to so arrange shape and color as to make the signal easily recognized. Each ship should repeat the signal when understood, and the haul down should be the signal of execution."

I am inclined to think that whether there is an official "battle code" or not commanders-in-chief will invent codes of their own before going into battle. It is trusting too much to the chances of our code being known to the enemy if published in a signal-book. Lieutenant-Commander Wainwright's code might therefore be as good as any other if it did not involve the really vicious principle of dipping flags to indicate certain meanings. It seems to me that the logical way to make the 21 signals he gives is to make them by regular code with the regular flags, and at the same time I don't think his 23 signals cover the case. The repeating back of signals is an excellent thing. A signal might be shot away when hoisted and before answered by all the ships. The hauling down of a signal is of course the signal of execution, but tactically or otherwise a vessel should never put her helm over without indicating it to her consorts by her whistle. It is always an additional check on the signal being understood.

The essayist says also, "The only formations needed are column and line, the echelon being formed from line or column, the vessels being drawn up in the line of bearing in one or the other of those formations and then turning together 45 degrees in the desired direction." On this text an essay might be written. We have in our tactics now a mixture of the direct and the rectangular movements. I should be glad to see all the direct movements stricken out except such as are indispensable (there are several). I think that echelon is best made from line or column on a line of bearing. If vessels are in line at distance (400 yards), and echelon is formed by the direct method to the front, there is a general change of speed, and when the vessels are in echelon the oblique distance between them is 566 yards. If column is now formed by a half turn the distance is 566 yards instead of 400 yards and there must be a general closing up. In changing formations direct methods unduly increase the chances of collision and require more care and judgment in their execution.

In the manœuvres of the fleets A and B in the tactical illustrations in the essay, I don't think the author emphasizes enough the advantage of getting and keeping the weather gauge where there is a choice in flank movements.

However, any one must be very ill-natured indeed who will quarrel with Lieutenant-Commander Wainwright on his excellent essay, and I, for one, am very much indebted to him.

Lieutenant J. H. GLENNON, U. S. N.—In regard to the echelon formation which the prize essayist advocates it may be remarked that, referring to Fig. 1, the vessels of the B fleet should, at extreme fighting range or near there, left turn. The vessels of the A fleet would then be compelled to turn to the right. In case they do not, but half turn or keep straight to the front, the B vessels, before or when the leader arrives on the line of bearing of the A vessels, should change simultaneously to the heading of the A vessels, after which, unless A changes his formation, the signal might be made to B vessels to follow the movements of the enemy as to speed and direction.

First, supposing that A, when B's vessels left turn, turns so as to run parallel with B. If we draw lines from all of B's vessels to A's nearest vessels and then operate similarly with A's vessels we will see that the average range from B's vessels to any of the nearer vessels of A is less than that from A's vessels to the nearest of B's, though with the vessels farthest off the opposite is the case. Now, the object in a gun attack is to get more of your vessels within fighting range of some part of the enemy than he can get on any point of you, and therefore I believe that B has the advantage of position. In short, A in advancing in echelon, leading vessel in front of any part B, is really presenting his flank, and B should simply endeavor by running away, turning or changing his formation if A does, to hold on to that flank. All this is not said in any spirit of criticism, but is supplementary, if I may so put it, to what the author has written. He has not, I think, sufficiently considered the possibility of B's running away; B might go slow in the latter case, as he will lose nothing by close quarters, but will have the advantage both in guns and torpedoes, and with sea-room he will have absolutely nothing to fear from the ram.

All must admire the author's courage in presenting a consistent scheme of battle tactics and his wonderful fertility of resource in handling the questions put to the Institute by Mr. W. Laird Clowes.

There is one thing in battle that may frequently be of prime importance, and that is "interference," the interference of the Chen Yuen between the Ting Yuen, which was on fire, and the Japanese fleet at the Yalu for example. The King Yuen might possibly have been saved in the same way. Vessels will frequently become powerless through fire, and may be from sudden large loss of their fighting force and in other emergencies. A signal in time to a friend to keep between you and the enemy may often save your ship and the battle. In closing I may say that the group formation and battle, something similar to the present skirmish drill for infantry, has points well worthy of notice. The field is the sea, the perfect level to which this species of fighting is particularly applicable.

W. LAIRD CLOWES.—I greatly regret that time will not now permit me to discuss at any length the Prize Essay which has been sent in by Lieutenant-Commander Richard Wainwright, U. S. N., whom I heartily congratulate upon his deserved success. He has, I venture to think,

admirably distinguished the limitations of the teachings of the past. These are, I fear, too often lost sight of. I have myself noticed in recent controversies in which I have been engaged a tendency on the part of my opponents to hurl Nelson and Hawke at me on much too slight provocation. It ought, surely, to be our endeavor rather to try to imagine what the great commanders of old times would now do were they in our position with our matériel, than to seek slavishly to adapt our matériel to their tactical principles. In this respect Admiral Ito, at Hai-yun-Tau, seems to have hit the happy mean. He adapted the principles utilized by Nelson at the Nile and at Trafalgar—the principle, I mean in particular, of doubling on and crushing a part of the enemy's line as a preliminary operation—to modern conditions. That such a system of attack ought, if possible, to be still applied has been the opinion of all our recent British tactical writers; but I do not know that one of them has succeeded in laying down any set of rules whereby the end in view may be attained. Nor, I suspect, are any rules on the subject now capable of the broad kind of application which attached to similar rules in the days of sailing ships. Conditions are now so much more variable and diverse than they used to be. In the rapid improvisation of adequate methods lies the true genius of a naval tactician; and although a few old base principles remain unalterable, we must depend daily more and more than we did upon the cool head, the originality and the instant decision of a commander-in-chief, and less and less upon mere traditional modes.

The essayist, while giving full value to the gun as a tactical weapon, allows, I think, too much value to the ram and far too little to the torpedo. I regard the career of the ram as ended. The fear of the torpedo and the terrible effect of heavy-gun fire at short range are factors which cannot but tell for many years to come and which must inevitably render close action, in the old sense of the words, between large modern vessels very infrequent, even when one party has a superiority of speed sufficient to enable him to select his distance. But effective action cannot be maintained at much greater range than 4000 yards, and at that distance, even in daylight, torpedo-boats, lurking under the lee of the big craft, have, I am fairly convinced, splendid chances, particularly if handled as American and British officers—so far as one can judge from their past exploits and their present character—could handle them. It was mainly the presence, towards the conclusion of the engagement, of torpedo-boats with Admiral Ting's shattered force that decided Admiral Ito not to attempt that which, no doubt, he might have otherwise accomplished; I mean the total destruction of the Chinese fleet. But the torpedo, to be a really potent factor, needs even something more than good men to handle it. If employed from boats, the boats must be fast, to begin with, and must have been carefully looked after, so as not to have materially deteriorated; if employed from ships, the torpedo-tubes must be either submerged or protected by armor. I venture to quote in this connection a passage from a carefully compiled account of the recent hostilities in the China seas, which

I have contributed to the as yet unpublished edition of Lord Brassey's "Naval Annual" for 1895: "All the Chinese ships went into action with torpedoes in the tubes and second torpedoes, without pistols, ready in the loading trolleys. But when presently shots began to enter the above-water torpedo-rooms the people took off the heads of the spare torpedoes and stowed them below; also, in some vessels, flinging the pistols overboard. In the Chen Yuen, a little later, several torpedoes were discharged to sink immediately, as their presence was supposed to constitute a danger to the ship. Immediately afterwards the stern tubes were actually struck by a Japanese shell. In the Ching Yuen, for the same reason, the torpedoes were hurriedly discharged, but not so as to sink, and two of them were picked up after the action. Whether the same thing happened in the Chih Yuen and King Yuen is not known, and, consequently, it cannot be determined whether or not the sudden catastrophe to the Chih Yuen was, as has been suggested, brought about by the explosion of a torpedo in one of her broadside tubes, but it is very probable that it was so." It should be added that all the experiments of which I have any knowledge—and these include a considerable number of which I have been a witness—lead me to suspect that a determined torpedo-boat attack, even by daylight, would not be so utterly hopeless an affair as is commonly imagined. If the boats, taking advantage of a lee afforded, say by ironclads or by neutral vessels (and one must admit the possibilities that neutral craft may be so used), could get within 2000 yards of their prey, not only, so I believe, would they succeed in a large proportion of their attempts, but also they would succeed with remarkably small loss. Even at 4000 yards, if helped by smoke, their prospects would be good. Modern boats, it must be remembered, and especially those of the "destroyer" class, are good sea-keepers and have a very respectable radius of action.

With the essayist's suggestion that, in certain circumstances, it would be desirable to substitute for the present long guns weapons of less length and greater caliber, I cordially agree; indeed, I have myself advocated something of the kind. For some vessels an armament of R. F. guns and B. L. howitzers seems to be peculiarly indicated.

I feel complimented when I see the large space which has been devoted by Lieutenant-Commander Wainwright in his paper to comments upon the various questions which I was permitted to formulate in No. 70 of the Proceedings. I am only afraid that he has given too much attention to points which will inevitably be answered by every commander in his own way when the moment for action arrives. My object was rather to suggest subjects for thought than to suggest topics whereon conclusions of a "regulation" character ought to be formed. I regard, however, as well worthy of attention the advice that war-ships shall carry collapsible boats either behind armor or below the protective deck.

Lieutenant-Commander WAINWRIGHT, U. S. N.—In endeavoring to reply to the criticisms in this discussion great difficulty is encountered in

keeping the matter within reasonable space limits. The field is wide and there is ample room for reasonable differences of opinion, so that to properly state any one side of the question would frequently require the limits of an essay. The one raised by Commander Goodrich is of great importance, and many pages of the Proceedings could be filled in fully developing the subject. If in this discussion I fail to reply to any criticism it is not from want of appreciation of its importance, but because time and opportunity do not permit.

First as to the place and functions of an armored cruiser or battle-ship of great coal endurance. I believe it is but a substitute or make-shift for a heavily armored battle-ship of limited coal endurance. A homogeneous fleet of an inferior type of battle-ships would be better than a heterogeneous fleet with ships on the average of a somewhat superior type. The importance of this tactical fact cannot be exaggerated; but the absence of coaling stations requires that the United States should have some vessels of this type. It is possible that even with sufficient properly protected coaling stations that the time consumed in coaling may be of sufficient importance to require in some a sacrifice in defensive armor for the purpose of greater coal endurance.

I do not believe with Lieutenant-Commander Schroeder that it is a valid reproach to the echelon formation that it is not elastic, and that before entering another formation the squadron has to form line or column; for the reason that I believe line, column and echelon to be the only formations for battle and therefore no greater elasticity is required. As to the distances being sometimes thrown out in entering or leaving echelon formation, this only occurs when echelon is formed to the front from line or line formed to the front from column. This should not be done in the face of the enemy. In fact, the line of battle consists of line ahead, or column, line abreast, or line, and bow and quarter line or echelon, and the only changes of front permissible in face of the enemy are those made by vessels changing direction simultaneously or with vessels in column by change of direction in succession following head of column, the distance in all cases between vessels remaining unaltered.

Lieutenant Meigs is certainly correct in his statement of the necessity of increasing the rapidity of ammunition supply, and it seems as if some system similar to that used in libraries for the delivery of books might be adapted to this purpose. In any case, for the complete development of rapid fire, a supply of ammunition must be kept on hand at the guns. Ordinarily the occasions when it is advisable to use extreme rapidity of fire would be few and last only a short time; in other words, the ready magazine would be used only as an emergency similar to the use of the magazine of small arms.

The adoption of shorter 16-in. guns for the high-powered 13-in. guns may be advisable. At present it would be prevented by the greater length of time between fires owing to increased weight of projectile and of breech block. Improved methods of handling ammunition and loading, and the adoption of rolling breech blocks, may overcome these difficulties.

Professor Alger has erected his own man of straw and then successfully knocked him over. I hardly think that any seaman would contemplate pointing otherwise than at the center of the target when distant 2000 yards; but as I believe that the crucial portion of the combat will be fought usually at less than 1000 yards distance, the point at which to aim becomes important. Chance shots at the opening range may inflict some damage, but it is at close range, within the danger space of the guns, that one vessel will silence the fire of the other and then drive her off or destroy her. The essay might have been clearer upon this point.

Lieutenant Niblack does not believe in unbending chains. I think that it would be dangerous to depend upon cutting stoppers and running the chain clear to the bitter end, as would be necessary should the anchor be let go by a collision. The mere act of bending the chains when they are not run below to the lockers is not a serious task. A compromise might be adopted and the chain unshackled abaft the bitts, unless there were gun positions forward of them, when the swaying end would be a danger in case of letting go.

Lieutenant Niblack's suggestion as to the application of a field telephone service to ship's uses is admirable. I do not think range-finding in action by any of the present methods, except with the guns, is of much importance to the gunners, and I have great doubts as to the importance of the weather-gauge. With modern vessels, running at high speed, it will be a strong breeze that makes the smoke obscure the enemy. I think the question of handling the guns in a seaway and that of exposure below armor belt are more important. The lee-gauge at times might be objectionable from the increased exposure below the armor belt, and it might be an advantage as allowing the guns to be handled with greater facility.

Mr. Clowes evidently believes in under-water torpedo-tubes or he would not adhere to the point that the fear of the torpedo with the gun fire will render close action very infrequent, for he admits the inefficiency and sometimes danger of above-water tubes. I believe that submerged tubes are at present inefficient and that torpedoes are of little value on cruisers or on battle-ships, and that in spite of "the terrible effect of heavy-gun fire at short ranges" the battle will be finished frequently at very close range. Therefore ramming will be an important factor and one necessary to be considered carefully in the present state of naval weapons.

It is especially pleasing to me that Mr. Clowes believes that I have been able to distinguish the limitations of the teachings of the past, for in that particular my able critic in the New York Herald thought I was in error and seemed to believe it even more dangerous or useless to apply the facts gained from the history of past naval battles to the conduct of modern conflicts than to apply the history of stage coaches to the conduct of railroads. Although only slightly acquainted with the subject of stage coaches or of railroads, I venture to assert that if one were unable to obtain the benefit of the experience of the methods in use

at present in railroad affairs he would be benefited greatly by searching through the history of stage coaches and ascertaining the rules that then governed the transportation of people and freight and then endeavoring to modify his rules so as to satisfy modern requirements. Without doubt, experience in battle with modern weapons can alone settle many problems, but it is certain also that the best substitute for experience with present weapons is the study of former battles. I do not believe that there is any danger of being induced by such study to misapprehend the great changes in weapons in the elapsed time.

Lieutenant Glennon's criticism of the movements of the A and B fleets is quite just as far as he goes; but he has only made another move for the B fleet, and A must make the proper reply. Should the right flank of A not overlap B's flank, and should A turn in pursuit to the same course as B, the latter would have the advantage; but should A gain ground to the right by running in column along the line of bearing until his right flank overlaps B's flank and then turn in pursuit, the advantage would be with A. B may then endeavor to gain ground with the port helm, forcing A to give a stronger sheer, and the final result be to bring the two fleets in parallel columns running in the same direction, as will be generally the case with two fleets handled equally well. It is not necessary to carry in the mind the lines of fire of the different vessels to get an average distance. The fleet having its center nearest the flank of an enemy has the advantage in position, and one of the points for which to strive is to have the distance between your center and one flank of the enemy shorter than the distance between his center and either flank of your fleet.

I must take advantage of this opportunity to thank my friends for their pleasant compliments, especially those who have so kindly criticized the essay.

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WATER MOTORS AS MARINE DYNAMO DRIVERS.

By Lieutenant F. J. Haeseler, U. S. Navy.

It is desired to present for consideration the feasibility of the use of water motors on board ship for the purpose of driving the dynamos and also the ventilating fans. An outline of the proposed scheme is as follows: That there should be duplicate dynamos, of a *commercial high speed type*, designed for running at about the commercial speed when belt driven; these dynamos to be direct coupled to the shafts of water motors of the most approved and economical type in the market, and these motors to be actuated by water from the steam fire pumps, also in duplicate; the waste water to be pumped overboard by a pump in the dynamo room, or pumped into the flushing system with an overflow, or to be returned through a return pipe to the pump in the fire room. In the following comparison the last of these three methods will be chosen to illustrate the working of the system.

In connection with the above outline the points to be considered are: 1st. Original cost; 2d. Expense of maintenance; 3d. Advantages and disadvantages.

First—Original Cost.

With reference to the expense of installation, the only considerations are those involving changes; the wiring, fixtures, etc., remaining the same, the cost of the generating set only is to be considered. The cost of the piping will be practically the same, for while it will take slightly larger pipes for the water than for the steam, yet there will be saved the cost of the separator and reducing valve, which together will easily cover the additional cost of the increased size of the pipes. The articles that will be dispensed with by using the water system will be the dynamo room electric motor and fan, the separator and the reducing valve. It will be

necessary to increase the fire pumps in size over what they would naturally be for the ordinary service for which they are intended, and in the table at the end of this paper, under the head Steam Pump, is meant the *increase* in size of pump necessitated. By reference to the table just quoted it will be seen that the cost of the complete generating set of the steam system is $6500, while that of the water system is but $1380, showing a saving of $5120 on *each* of the generating sets of the ship. The prices given in the table were obtained as quotations direct from the manufacturers and are correct.

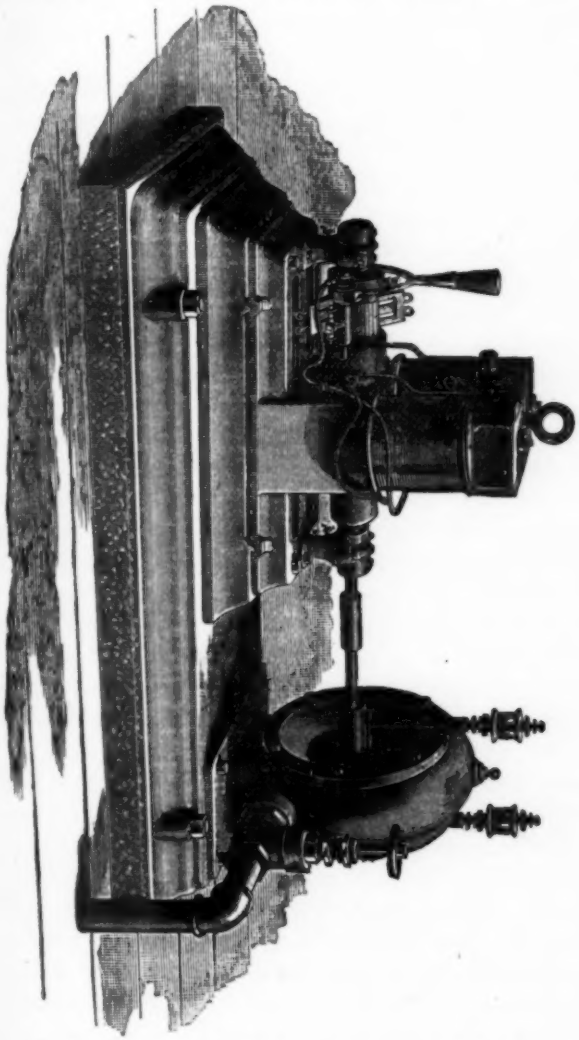
Second—Cost of Maintenance.

This head is subdivided into Efficiency, Attendance, Repairs, and Lubricants.

Efficiency.—The specifications of the Bureau of Equipment require for the different sizes of the generating sets efficiencies varying from 76% with the 8 kilo-watt set to 82% with the 32 K. W. set, *at full load.* It will be seen by the table already referred to that the efficiency of the steam plant *at full load* is greater than that of the water system; but *at half load*, which is about what is carried nineteen out of the twenty-four hours, the efficiencies are about equal, or slightly in favor of the water plant. The above comparison is made allowing that the efficiency of the steam engine remains as high as when tested on shore before installation, which I have no hesitancy in saying—and experience has corroborated my statement—it does not. Further, the use of a slow speed pump admits of the installation of a compound steam end, which will result in a saving of at least 20% (pump makers claim 30%) in fuel, which, after all, is the only true basis of comparison. The water motor and dynamo will be as efficient at the end of a cruise as they were the day they were installed, and the fire pump being a slow running machine, with very little friction and very few parts, and being driven at less than half its maximum speed, should have very little wear, so that the efficiency of the entire plant should remain nearly as high during the entire cruise as it was when first tested. The details of the computation of the data in the table referred to and the data of the tests made of the Pelton Water Motor are given in an appendix to this paper.

Attendance.—At present we have at least three, and generally

four, gunner's mates to attend the dynamos and engines on board ship. On a vessel carrying duplicate 24 K. W. sets, there would be two gunner's mates, first class, at a pay of $40 per month each,



WATER MOTOR WITH DYNAMO CONNECTION.

and two gunner's mates, second class, at a pay of $35 per month each, or a total cost of attendance of $150 per month. By the introduction of the water system, the expert attendance needed *only* by

the high speed engine would be unnecessary, and one of these gunner's mates, first class, and both of the gunner's mates, second class, could be replaced by apprentices, first class, at a pay of $21 per month. This would leave the one gunner's mate, first class, in charge and to attend to the repairs to the wirings, search lights, fixtures, etc., and the three apprentices would stand watch in the dynamo room. This would effect a saving of $47 per month, which represents about 25% of the coal bill of the dynamos. Further, it would help in giving electrical instruction to all the seaman apprentices, first class, of the ship.

Repairs.—The experience of the users of the water motors of the Pelton class shows that absolutely no repairs are necessary, while the repairs on the pumps will probably be no greater than those arising from the wear and tear on the flushing and fire pumps which they replace. The pumps would, of course, be designed for the work to be done, and should have very little repairs; and it is well known that pumps if run much below their maximum capacity will keep up their efficiency for years of steady running, with an occasional renewing of the packing or the refitting of the valves. On the contrary, the marine dynamo engine is constantly being repaired and its parts renewed at considerable cost. In all the reports from the Bureau of Equipment on the subject of "Electricity on Shipboard," the breakages of the engines take precedence in the list of accidents to which the generating set is liable. In doing away with the high speed engine and substituting a machine that is practically indestructible in use and never needs repairs, we do much towards making the plant perfectly reliable.

Lubricants.—The present method of running the dynamo engines without oil in the steam spaces reduces the consumption of oil very considerably, but it is very questionable whether it does not do so at the expense of the engines themselves. I am fully aware that engines can be and are so run, and that the interior of the cylinder gets a beautiful polish on it, and shows no sign of wear after long use; but that is the case on shore where the engines are fixed to firm foundations, get the best of care by trained men, and are not tossing about, frequently at an angle of 30°. But even without the use of oil in the steam spaces the marine dynamo engine has a dozen oil cups where the water motor has two, and without having any data at hand that will

positively show what the saving in oil would be, it is a very safe estimate to say that there would be required less than one-half the amount of lubricants in the dynamo room that there is at present.

Summing up under the head of cost of maintenance, we see that the efficiency of the proposed system would be *at least* equal to the present, that the saving in attendance, repairs and lubricants is marked, and that therefore the cost of maintenance of a plant on the water system would be less than on the steam system at present in use.

Third—Advantages and Disadvantages.

The evident *additional* advantages of the water system over the steam system are as follows:

1st. Ordinary temperatures in the dynamo room.

2d. Absence of dirt and oil in the dynamo room.

3d. Absence of thumping of engines in the dynamo room.

4th. Great reduction in weight (see table).

5th. Reduction in the space required for dynamo room.

6th. No need of carrying spare parts.

7th. No lagging of pipes nor expansion joints.

8th. Possibility of replacing dynamo or motor in any market.

9th. No danger to human life due to defective or ruptured pipes.

10th. Possibility of coupling either dynamo to either motor, or both dynamos to the same motor, or both motors to either dynamo, and, if desired to run both dynamos at exactly the same speed, both motors and both dynamos could be all coupled together.

These advantages require no explanation nor data to show that they would exist; they are self-evident, and the first-mentioned, that of absence of all unusual heat in the dynamo room, and therefore on the berth deck or other living spaces or store rooms in the neighborhood, is of enough importance in itself to merit an investigation into the claims made for this system.

In connection with this subject there are two points not yet touched on: that of governing and that of reserve power. Of the former I *know* that the Tuerk or Syracuse Water Motor will govern as efficiently as the present steam engine governor; but the efficiency of this motor is so low that it would cost too much coal to run it, and, further, it has a more delicate and intricate

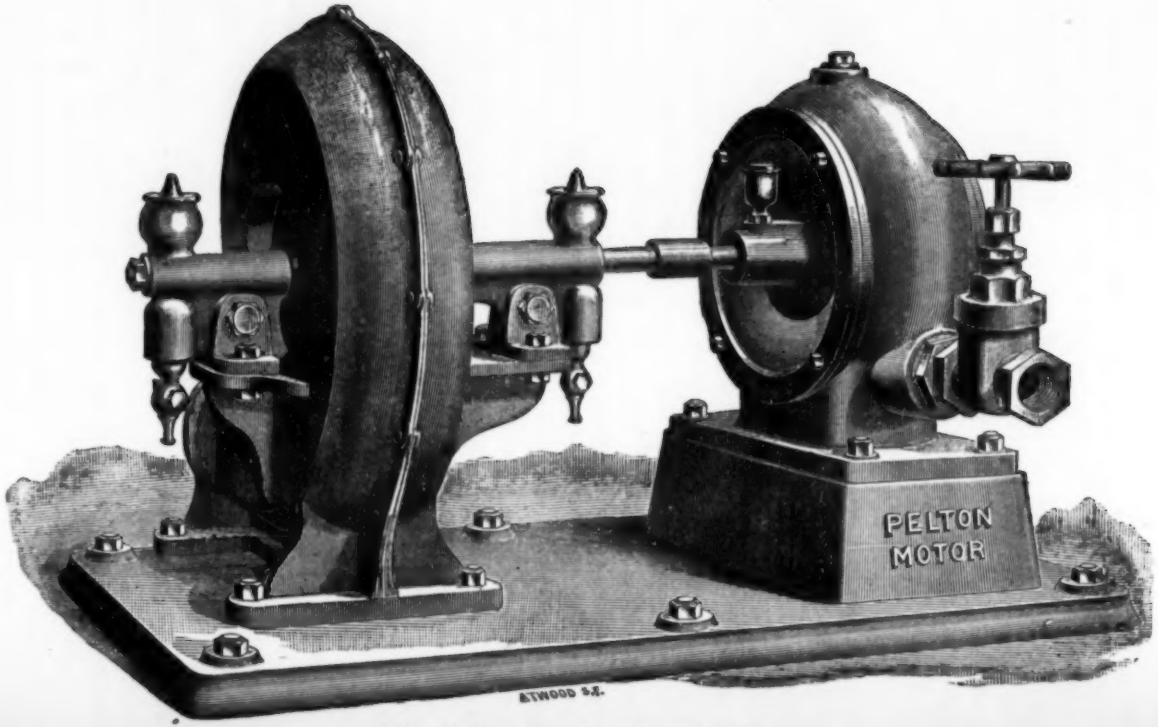
construction, one that might get out of order, and would require a certain amount of attendance. The testimonials published by the Pelton Water Wheel Co. go to show that they also have a perfectly reliable governor. It is unfortunate that I have not as yet had an opportunity of testing the Pelton governor to see if it would meet the requirements of the Bureau of Equipment for governing. The small governor made by this firm will meet all demands on it from full load to no load, if the load is not varied by too large a quantity; but it would be a very simple matter to have a test of the Pelton differential governor made, so as to see just how well it would meet the demands. If their governor meets the claims of the Pelton Company as well as their wheel does, it will be all that would be necessary. At the same time I am inclined to believe that a much simpler governor could be designed, something on the general plan of the Willans steam governor, and I have sketches of two designs for this purpose: one controlling the valve motion by electricity, and one by the speed of the motor shaft. If it was found that the electrically controlled governor would work satisfactorily, it would admit of the discarding of the hand regulator in the shunt, and then the *only* duty of the attendant would be to fill the three or four oil cups on the generating set and see that the dynamo brushes were properly set. Either of the designs of governor just mentioned would require no power to run them except at the moment of use, with the exception that the shunt coil of the electrical governor would take probably 20 watts to keep it excited, which amount of power would be practically nothing.

Reserve Power.—A water motor has a wider range of power, at a high efficiency, than any other class of engine. It is simply a question of the amount of water that can be provided for it. With the same Pelton wheel I have obtained 16-horse power at an efficiency of 86%, and ¾-horse power at 82% efficiency. Where is there a steam engine that can equal that performance? This same motor is capable of developing at least 60-horse power at the same high efficiency. It therefore becomes a matter of how much water the pumps can provide. In the pumps selected in this comparison, either pump, without running at its maximum speed, is large enough to run both motors with power enough to drive both dynamos to their full capacity. If, therefore, either pump was to break down, the other would be equal to the emergency in the very rare case of the necessity of running both dynamos.

Another advantage not mentioned is the possibility of starting up the generating set in a few seconds. With the steam set, if anything happens to the dynamo or engine it becomes necessary to warm up the other engine before it can be started, which requires at least five minutes, during which time the entire ship would be in darkness, which might delay the supply of ammunition or the training of the guns at a most critical time, or cause great confusion in the engine room.

The Ventilating System.

It is generally conceded that the present system of ventilation is wrong. We have the tremendous air ducts running through the ship, occupying berthing or coal space and, in all probability, ruining the water-tight bulkhead system, and the engines driving the ventilating fans of this system use steam, thereby heating the living spaces and store rooms by their admission and exhaust pipes. The fans must be run on the entire system in case an improvement in the ventilation is desired at any one point, and as the air inlets in each store room *will* be left open, the unnecessary work done is great. It has therefore been advocated by many officers of the service that between every two water-tight transverse bulkheads a separate blower be established, and that these blowers should be run by electricity. This would be a great improvement, but it would be still better to run the blowers by water motors. By the use of the latter there would be a number of advantages: first, a saving in coal, as the small water motor is more efficient than the small electric motor; second, a saving in cost, as an electric motor having the same power as a water motor would cost six or eight times as much; third, a saving in weight, as the same relation would hold as in their cost; fourth, the water motor would need absolutely no attendance, merely filling the oil cups once every four hours would be all the attendance necessary. With the electric motor, theoretically, no attendance is needed, but it is very liable to be damaged unless entirely encased, in which event it is very likely to heat excessively; and while the brushes, if once properly set, should require no further attention, still if a little dirt should get on the commutator, and it was not removed, it would be a matter of a very short time before the entire surface would be ruined, requiring turning down in the lathe. In the



FAN BLOWER RUN BY WATER MOTOR.

event of a hot bearing of the armature it will either slow down and burn out, or the fuze will blow, which is not desirable, as it would be at least a 20 ampere fuze, and that in itself would be liable to set fire to some of the woodwork in the neighborhood. In case of a hot bearing with a water motor, an event much more rare than with an electric motor, the machine would slow down and no damage would be done. The only advantage the electric motor has over the water motor is the ease of conveying the power to it,—wires in the one case and pipes in the other.

I have given an outline of the system of water motors that could be used on board ship, and the more the matter is looked into and discussed, the more apparent the advantages become. The water motor could be applied directly to the anchor hoist, saving a large amount in cost and weight; and, as in this event it would be located above the water-line, the waste water would run overboard, so there would be the saving of one pipe in case the exhaust is connected to the condenser, which it usually is. Here again comes the saving of undue heat in the living spaces, as every one knows what a nuisance an anchor engine is, on account of the heat given off by it for hours after it has been used. I think, however, that the advantages of the use of a water motor are nowhere so apparent and real as in running the dynamos and ventilating fans, even if the present system of large fans is continued.

	24 K. W. Naval Dynamo.	Dynamo Engine.	Complete Set without Dynamo Room Blower.	Complete Set with Dynamo Room Blower.	Steam Pump.	High Speed Dynamo.	Pelton Water Motor.	Complete Set without Dynamo Room Pump.
Original Cost.....			$6500		$180	$900	$300	$1380
Weight.....	4608	2612	8800	9054	2200	2400	675	5275
Floor space.....			92″ x 45½″			50″ x 34″	14″ x 32″	64″ x 34″
Efficiency at full load.	90%	89%	80%	77%	90%	92%	86%	71.2%
" " half load.	85.6%	78%	66.8%	66.6%	90%	88.5%	82.3%	65.5%

In the column of Steam Pump abreast Original Cost and Weight is meant the increase necessitated in the fire pumps by the introduction of this system.

APPENDIX.

Comparison of Efficiencies of the Steam and Water Systems for Driving Dynamos.

The size of the generating set used as an illustration will be the 24 K. W. set of the present type, compared with a similar-sized dynamo driven by a 24-in. Pelton water wheel, using water at 150 pounds pressure and making about 700 revolutions.

The Dynamos.

The commercial efficiency of the present naval multipolar dynamo of 24 K. W. capacity is about 90% at full load, the losses being proportioned about as follows:

	Watts.	Per cent.
Shunt loss C^2R	778	3.3
Armature loss C^2R	833	3.7
Hysteresis, friction, etc.,	700	3.0
	2311	10

If now the load be reduced to one-half, the losses in the shunt and those due to friction, etc., will remain the same, or, summed together, will be 6.3% of the full load, or 12.6% of half load. The armature loss will be $(\frac{1}{2})^2 \times 3.7\%$, or .9% of full load, or 1.8% of half load, so that the entire loss will be 14.4% and the dynamo efficiency will fall to 85.6%.

For the high speed commercial dynamo for the water set, I have selected a 24 K. W. compound wound Lundell dynamo, running at 700 revolutions and having the same voltage as the present naval type. The compact and ironclad form of this make of dynamo, together with its very high efficiency, makes it particularly suitable for the work required of it. The losses are as follows at full load:

	Watts.	Per cent.
Shunt loss	684	2.5
Armature loss	800	2.95
Friction, etc.,	690	2.55
	2174	8

This gives a final efficiency of 92% at full load. At half load we have losses as follows: Shunt loss 5%, armature loss 1.45%, friction, etc., 5.1%, combined loss 11.55%, or the efficiency at half load falls to 88.45%.

The data for the Lundell dynamo were obtained directly from the Interior Conduit and Insulation Co. of New York and were from actual tests. As the dynamo was belt driven when tested, its efficiency would probably have been higher had it been connected direct to the shaft of a water motor, thereby saving the binding friction on the bearing at the pulley end of the machine.

There are many instances quoted by reliable authorities giving 94% and in some cases 95% efficiency for high speed dynamos. The General Electric Co. quote a 4 pole 25 K. W. dynamo, running at 1050 revolutions, on which it will *guarantee* 90% efficiency, but state that it will run higher than that figure. The C. and C. Electric Co. quote on a bi-polar 25 K. W. dynamo 91% as a guaranteed commercial efficiency. Therefore the 92% quoted by the Interior Conduit Co. is probably correct, and can easily be attained.

The Pump.

The efficiency of the modern direct-acting pump runs very high. Correspondence with the Worthington, Blake and Dow pump-makers establishes at least 90% as their efficiencies when everything is in good working order. At first thought this seems too high, but a little consideration and investigation will show that this is not unreasonable. An old-fashioned pump having 80% efficiency was considered very good; but that class of pump had a fly-wheel, crank, connecting rod, etc., and not as much thought had been expended on the details of the design; the openings were frequently insufficiently large and the valves were leaky. Further, the presence of the fly-wheel, so advantageous generally where unequal stresses were brought on a machine, was detrimental for two reasons: first, because its own weight and the action of the thrust of the connecting rod on the crank pin absorbed a large percentage of the work, due to friction; and, secondly, because the weight of the fly-wheel actuating the plunger of the pump, which was moving an *incompressible* and *inelastic* body, caused its power to be delivered like a blow, and there was great loss by impact; so that now, with a slow-moving, direct-acting pump, the

steam cushions its own blow, giving it the effect of a *push* instead, and with almost no friction, we naturally can expect and do get high efficiencies.

Professor Robert H. Thurston, of Cornell College, in an article on the Contemporaneous Economy of the Steam Engine, in the Transactions of the American Society of Mechanical Engineers for 1894, gives all the data of an actual test of a pumping engine having a commercial efficiency of 90.78%, and states: "The friction of the engine is remarkably low for this type of pumping engine, but it is, *of course*, still *above* the figure obtained from the best direct-acting machines, which, in the Newtown, Mass., trial reported recently, for example, was found to be 4.2%, giving a mechanical efficiency of .958 as compared with that here obtained of .9078." By friction of the engine Prof. Thurston means the difference in horse power between the I. H. P. of the steam engine and the hydraulic horse power of the pump, as the data accompanying his report show. He further states that the Newtown, Mass., percentage of efficiency is somewhat higher than usual. It sounds paradoxical, but a little reflection will show that the greater the number of expansion cylinders, the lower the efficiency of the engine; therefore for a duplex simple pump the efficiency will be higher than for a triple or quadruple expansion engine. The reason of this is that there being more parts to the compound engine there is more friction, and therefore lower mechanical efficiency, but when we compare the coal consumed, then the advantage of the compound engine asserts itself. Quoting from a letter from the Blake pump manufacturing firm, we have: "Under favorable conditions, when running at its maximum, the efficiency will be in the neighborhood of 90%, and when only doing one-half the work this will probably be increased to 95% or 94%. The enclosed tracing shows cards taken by the writer from a Blake triple compound pump, with steam jacketed high pressure cylinder. In this case the efficiency was 93.2%, which is quite remarkable when all the places where friction is produced are considered."

Mr. Dow, of the Dow Pump Works, writes: "We find the loss in I. H. P. of our non-compound direct-acting steam hydraulic pumps, as we have furnished the U. S. Gov. boats Oregon, Olympia and Monterey, to in no case exceed 10% at full capacity, and 5% at half speed. . . . The high efficiency you refer to, 95-96%, in large pumping engines is correct."

It is therefore safe to assume that the pump can have an efficiency at least as high as claimed for it, 90%, at *full load for the dynamo;* this will be but *half load* for the pump. The reasons the efficiency rises as the load is decreased in a pump are as follows: The friction depends directly on the pressure and speed, and as the speed varies directly as the amount of water required, at half load there will be but half speed, and as the pressure remains the same there will be just half the mechanical friction or the same loss per cent; but the water friction varies as the square of the velocity of flow, and as this at half load is half what it is at full load, the loss by friction will be but one-quarter. Therefore the efficiency should be and is higher. Still, to be on the safe side, I have taken the efficiency at *half load*, which will be only *one-fourth* the capacity of the pump, as 90%.

The Engine.

The efficiency of the high speed engine is about 89%, the loss being due entirely to clearance and friction. This loss, as the *speed remains constant*, is always the same; therefore at half load the engine efficiency will be 78%.

The Water Motor.

The water motor used in the before-described comparison is manufactured by the Pelton Water Wheel Co. of San Francisco and New York. I have tested other makes of water motors, and read of still other tests, and it has been my experience, as well as that of others making comparative tests with these motors, to find that they are at least 15% and in some cases 35% more efficient. The firm claims an efficiency of 85% when the wheels are set in accordance with their instructions, and I have found their claims not only true, but below what is really obtainable. During the past two months Ensign W. H. G. Bullard, U. S. Navy, and the writer tested one of the Pelton wheels bought out of stock two years ago, and without any expectation at that time of its being tested for efficiency. Tabulated below are the results of our tests, showing an efficiency at the higher pressures in excess of that claimed by the firm. Tests Nos. 1, 2, 3, 10 and 11 were made with the motor running at incorrect number of revolutions, in order to determine the efficiencies when governing, in case the pressure on the whole jet was reduced and the revolutions kept

up. Test No. 13 was the last one made, and it was noticed that the brake was binding closely on one side, which may have occasioned the lower efficiency.

TESTS OF PELTON WATER MOTOR No. 4.

Made by LIEUT. F. J. HAESELER, U. S. N., and ENSIGN W. H. G. BULLARD, U. S. N., at the United States Naval Academy, March, 1895.

Test No.	Size Jet.	Running Pressure.	Revolutions.	Water used. cu. ft.	Actual H. P. Developed.	Theoretical H. P. Possible.	Per cent Efficiency.
1	5/8"	90	775	14.05	4.101	5.496	74.6*
2	5/8"	105	910	15.14	5.025	6.910	72.7*
3	5/8"	100	850	14.78	4.694	6.422	73.1*
4	5/8"	100	775	14.78	5.349	6.422	83.3
5	5/8"	103	780	15.00	5.563	6.715	82.9
6	3/4"	125	880	23.05	10.73	12.52	85.69
7	3/4"	102	775	20.82	7.845	9.226	85.02
8	3/4"	100	775	20.61	7.756	8.957	86.59
9	3/4"	125	900	23.05	10.67	12.52	85.16
10	3/4"	73	775	17.61	4.457	5.587	79.79*
11	3/4"	86	880	19.11	5.365	7.143	75.12*
12	3/4"	100	780	20.61	7.717	8.957	86.15
13	3/4"	142	900	24.56	12.84	15.16	84.70

* Tests marked thus were made to find the efficiency of the governor.

A Prony brake was used, with a stream of cold water running over it all the time, and two pieces of soap bearing against the pulley, like the brushes of a dynamo, kept the brake equally lubricated, and the pull on the scale was very steady. The pull was measured by a spring balance, the brake arm being kept horizontal all the time, and the balance was compared with the standard after each test, and in several cases the standard itself was used. The standard balance was verified before and after the series of tests and was found to be accurate. The amount of water used was *absolutely measured* by running it into the pool of the natatorium of the Naval Academy, where the level of its surface could be measured by means of a float and rod that could be read with exactness to the one sixty-fourth of an inch, which corresponded to just one cubic foot. Thus the need of any formulae or miners' inch measurement was obviated. In this man-

ner a number of tests were made, and the coefficient of ajutage found to be 95% with the $\frac{5}{8}$-inch jet, and 92% with the $\frac{3}{4}$-inch jet, which agrees very closely with what they should be when worked out theoretically. After the coefficients were determined and found to be practically constant, the $\frac{5}{8}$-inch jet not varying 1% in a range of pressures from 20 to 100 pounds, and the $\frac{3}{4}$-inch jet not varying at all in from 15 to 50 pounds, the water motor was moved to the power house, close to the pump, so as to get rid of pipe friction and have the pressures more under control, and at the same time higher pressures were obtainable. The amount of water then used was determined by using the coefficients of ajutage found as already described. The efficiencies thus determined can therefore be taken as being reliable, and agree with those in testimonials published by the Pelton firm. In this connection it is a matter of interest to quote from a letter from the Pelton Water Wheel Co. on the subject of efficiency: "Regarding the efficiency of our wheel when carefully made, especially for test purposes, would say that several years ago we sent a special test motor to Professor Reuleaux of Berlin, who obtained an efficiency between 90% and 91% from same. . . .Referring again to the installation at Fitchburg, the efficiency shown by the wheels there is fully 86%, the power delivered by generator is easily ascertained from the station instruments, and taking the *theoretical* discharge of the nozzles—no allowance whatever being made for nozzle friction—the efficiency of the wheels was 86%."

The efficiency therefore of the water motor *at full load* is 86%. This loss of 14% is made up of several things: friction of machine, friction of water in buckets, loss by impact on edge of bucket, etc. Of these the friction of the machine alone remains constant, as the speed remains the same; as the water is throttled down the pressure is reduced, and to keep up the efficiency the revolutions should be reduced correspondingly; but this cannot be, as the speed of the dynamo must remain constant; hence the efficiency will fall to about 75%. (See tests Nos. 6 and 11.) Here we throttle 125 pounds and 880 revolutions down to 86 pounds and 880 revolutions, and the efficiency falls from 86% to 75%. This can be obviated in two ways: first, by using a number of jets, say four, two of them being fitted with throttle governors, and by automatically or by hand cutting out a jet when the throttling reduces the

power by an amount equal to the power developed by one jet. By this means we retain our 86% efficiency on two of the jets as long as the load is above one-half, so that we would have, at the lowest possible efficiency, two jets of 86% and one of 75%, or a combined efficiency of 82⅓%. Another and apparently simpler method of keeping up the efficiency, and one that I think is mechanically practicable, is to have one or more jets that can be varied in size of opening according to the power required. In this case the efficiency would not fall below 84%. But we will allow that we cannot get over 82⅓% at half load; hence we have 86% at full load and 82⅓% at half load as the efficiencies of the water motor.

Combining these efficiencies we have for the steam system at full load $90 \times 89 = 80\%$; for the water system at full load, $90 \times 92 \times 86 = 71.2\%$. At half load we have for the steam system $86 \times 78 = 67\%$, and for the water system $90 \times 88.45 \times 82\frac{1}{3} = 65\frac{1}{2}\%$.

But in every dynamo room where the dynamos are run by steam there is an electric motor and blower to help keep the room cool; the size of this blower varies from ½-horse power to 2-horse power, and as these small motors have not efficiencies over 75%, it will be safe to say that the average blower installed with a 24 K. W. set uses 1¼-horse power from the output of the main dynamo.

We therefore have finally for the efficiency of the steam plant, meaning thereby the ratio between the power produced at the dynamo terminals, less that required for running the blower, and the I. H. P. of the engine, at full load $89\% \times 86\frac{1}{2}\% = 77\%$, and at half load $78\% \times 79\% = 61.6\%$. In these combined efficiencies it will be seen that the power needed to run the dynamo room ventilating blower is taken into account in computing the efficiency of the dynamo where it is considered as a loss.

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THE GROWTH OF U. S. NAVAL CADETS.

By Henry G. Beyer, M. D., Ph. D.,
Surgeon U. S. Navy.

The study of the growth and the development of the human subject has always been one of great interest, not only to the physiologist and statistician, but also to the general reader. While, however, growth seems to be the most natural thing that occurs in the animate world and in living things, some of the mysterious laws that govern the process are still involved in obscurity.

One of the means for the study of *human* development is anthropometry. By it we are enabled to record the progress that has been made in the different dimensions from time to time, and, providing our material is sufficiently large, to form our conclusions accordingly.

Thus it has been the custom at the Naval Academy for the last thirty years or more to make an annual physical examination of every cadet in training at that school, and, at the same time, to keep a record of certain anthropometric measurements of every cadet undergoing such examination. As the material that has accumulated in this manner is now sufficiently large, it would seem as if it were a duty to attempt a systematic study of these valuable records, with the view of contributing something to our present knowledge of the subject of growth.

As regards the nature of the examination itself, it is well known to all interested in the subject of anthropometry from the items that are recorded, and needs, therefore, not be described in detail. Up to a few years ago the height standing, perineal height, circumference of chest, waist measure and the lung capacity were the only items recorded. Within recent years the height sitting, span of arms, strength of squeeze, acuteness of vision and hearing have been added to these records. The number of observations

under the first-named items is, consequently, much larger than that under the last named.

The fact that all the measurements are taken and recorded by medical men is sufficient guarantee of their accuracy and adds no little value to the results we may derive from them.

The cadet who stays the full term of four years at this school leaves on the books the records of five successive examinations taken one year apart; after graduation two years are spent at sea, after which time the cadet returns to the Academy for his final examination, leaving the records of another physical examination. This makes six in all. Since the age for entrance into the Academy is limited to from 15 to 18 years, and taking six years as the time necessary to elapse between the first and last examinations, the period of growth covered by these records ranges all the way from 15 to 24 years of age.

The circumstance that the cadets for the Naval Academy are appointed from all parts of the United States by their representatives in Congress ought, in our opinion, to add considerable weight in our attaching to whatever means or averages we may derive from their measurements a certain value, more national in character than can be attributed to the means and averages derived from the measurements of merely local schools and colleges. Besides, another point that is calculated to make our records particularly valuable is the fact that a large percentage of them are continuous records. The number of cadets that enter annually may be said to have varied in the past between 60 and 80, and that of those who graduate between 30 and 40.

It is perhaps also of some importance to mention the fact at the beginning that, from the great preponderance of blue eyes and light brown hair prevailing among Naval Cadets, it is safe to state that the great majority of them are of Anglo-Saxon and Teutonic origin. It is not impossible that the school may have exercised and is still exercising a certain degree of selection from that type of men for its devotees.

Statistical Methods.

One of the greatest impediments to our progress in the study of growth in this country has undoubtedly been due to the fact that different observers have used different methods of recording the results of their investigations, and, consequently, these results are difficult of comparison.

As regards the methods of investigation used in the present inquiry and those of recording its results, I have adhered to those used by Prof. W. T. Porter in his work on the "Growth of St. Louis Children" as closely as possible and with the view of making my statistics strictly comparable to his.

A brief outline of these methods and our conception of them seems, therefore, essential.

Based on Quetelet's statements made many years ago, it has since been most generally assumed that all anthropometric measurements would be found distributed according to the laws of chance; that a large number of measurements, for instance, of the height of man would arrange themselves on either side of a true height. It has, furthermore, been assumed that this arrangement would be symmetrical on either side of the true height if the number of observations were infinite and if only accidental influences had been at work in each individual measurement in a given series.

Quetelet's theory has since been further developed by Stieda and Ihring and also by Galton. In the same manner Bowditch and Porter have adhered to the theory of Quetelet, and all their investigations are based on this theory.

Quite recently Boas has made the following remarks regarding the theory of Quetelet, viz: "Glancing over the curves representing large series of measurements, it strikes me that they conform to the laws of chance only in a general way and that considerable deviations occur quite frequently. . . . Assuming that there is a uniform ancestral type in a certain district, and that the conditions of life remain stable, we may expect that the people representing its offspring will be grouped around the type according to the laws of chance. Assuming, however, that there were two distinct ancestral types in adjoining districts, and that these types intermingled, we cannot foretell what the distribution of forms among the offspring will be. It may be that they will represent an intermediate type between the parental forms, in which case we might expect to find them distributed according to the laws of chance. But it might also be that they showed a tendency to reproduce one or the other of the ancestral types either pure or slightly modified, in which case the resulting curve would not conform to the laws of chance, but would show an entirely different character."

This view seems to be well taken and deserves our consideration all the more for the reason that the intermingling of different varieties of the same species is a well-known cause for variation. In view of cautionary signals such as the above, some comfort may perhaps be derived concerning our present material of observation from the fact above mentioned, that the preponderating racial type of man under investigation is undoubtedly Teutonic in character. At any rate, a sorting out of types different from the prevailing one being entirely out of the question, especially in the absence of all craniometric data, we have been obliged to follow the example of previous investigators, and will make a brief statement of the various methods employed in the present inquiry, hoping that whatever correction may have to be applied may apply to all alike in the future.

In Table I* are exhibited the observed distributions of the heights of 842 Naval Cadets aged eighteen years.

AVERAGE.—The average (A) was calculated according to Stieda, quoted by Porter, and which means the quotient obtained by dividing the sum (Σa) of the values (a) obtained in the individual measurements by the whole number of observations (n): $A = \frac{\Sigma a}{n}$. The adjoining Table II will illustrate the method.

MEAN or MEDIAN VALUE (M) can sometimes be found by the simple inspection of a series, if the number of observations is sufficiently large, but is more exactly determined by the following method, viz: The mean strength of squeeze of the right hand in Table II is obtained by adding the number of observations from above downwards until the sum cannot be increased by the next number in the column without exceeding half the total number of observations. Thus 111 is reached opposite 75 pounds; the next number below in the column (40) would make the sum 151, which is more than half (112.5) of the total number of observations (225). The mean is, therefore, greater than 75 but less than 80 pounds. Its exact position is found by interpolation. Half of the total number of observations is 112.5, which is 1.5 more than the observations up to 75 pounds; 1.5 is 3.7 per cent of 40, the observations at 80 pounds. Hence the mean is 75.46.

* The tables referred to will be found in the Appendix.

Some statisticians take the average to be the nearest approach to the typical value, and this seems to be the case whenever the distribution of measurements follows the laws of chance; others look upon the mean to be the better value as representing the type, while still others hold that neither of these values in their present application represents the true type. Bowditch says: "If *A* represent the average value of all the observations, then the value of *M*—*A* will be a measure of the direction and extent of the asymmetry of the curve *ST* (curve of percentile grades), for this value will be zero when the curve is symmetrical, positive when the values of the lower percentile grades fall short of *M* more than those at the higher grades exceed it, and negative when the reverse is the case." An examination of his table and of the curves constructed from it shows that the asymmetry of the curves of percentile grades varies very much at different ages both in direction and amount. Bowditch states distinctly that "we must conclude, therefore, that the rate of annual increase, both in height and weight, is different at different percentile grades, or, in other words, that large children grow differently from small ones, and, moreover, that between the ages of eleven and fifteen years there is a striking difference in the mode of growth between the two sexes." We will refer to this point of the difference in the growth between tall and small children in some detail later on.

THE PROBABLE DEVIATION.—But neither average nor mean gives us any information as regards the manner in which the individual measurements of a series are distributed, and it is clear that two series with an identical mean or average may yet differ largely in respect of the dispersion of the individuals from the middle value, as the following numbers, taken from Porter, will show:

4, 5, 6, 14, 15, 16.
9, 9, 10, 10, 11, 11.

These have the same average (10).

A very convenient measure of the degree of dispersion or deviation of the individual members of a series from their common mean or average is that afforded by the "probable deviation."

Probable deviation (*d*) is that deviation from the middle value

which, in a large series of observations, is as often exceeded as attained (Lexis, Porter). According to Boas, the *mean deviation* is more accurate than the probable deviation, which is no doubt true. Inasmuch, however, as the relation between the two must be constant, and as it was one of our objects to make the results of our investigations comparable with those of previous investigators, the preference was given to the probable deviation which was calculated in accordance with the following approximation formula:

$$d = \pm 0.8453 \frac{\Sigma \delta}{n}.$$

In accordance with this formula all the individual deviations from the middle value (average or mean) of a series must be added together without regard to whether they be plus or minus, and the sum divided by the total number of observations as shown in Table III.

The observed distribution shown in Table III must now be compared with the distribution of the observations of an hypothetical series constructed according to the calculus of probabilities. The observed and the theoretical series should correspond, providing the causes of the deviations are purely accidental. Since it is absolutely required that such a comparison must be made before it can be known whether the observations in any series can be treated by the methods of the theory of probabilities, Table IV is appended.

This table apparently shows that slight deviations do occur, and Bertillon proved this some time ago. Bowditch, also, has shown that the curves, showing the distribution of statures and weights of children, do not follow the laws of chance, by having pointed out the fact that during the period of growth a constant difference exists between the average and the probable values, an observation which we have also been able to confirm, as will be seen later on.

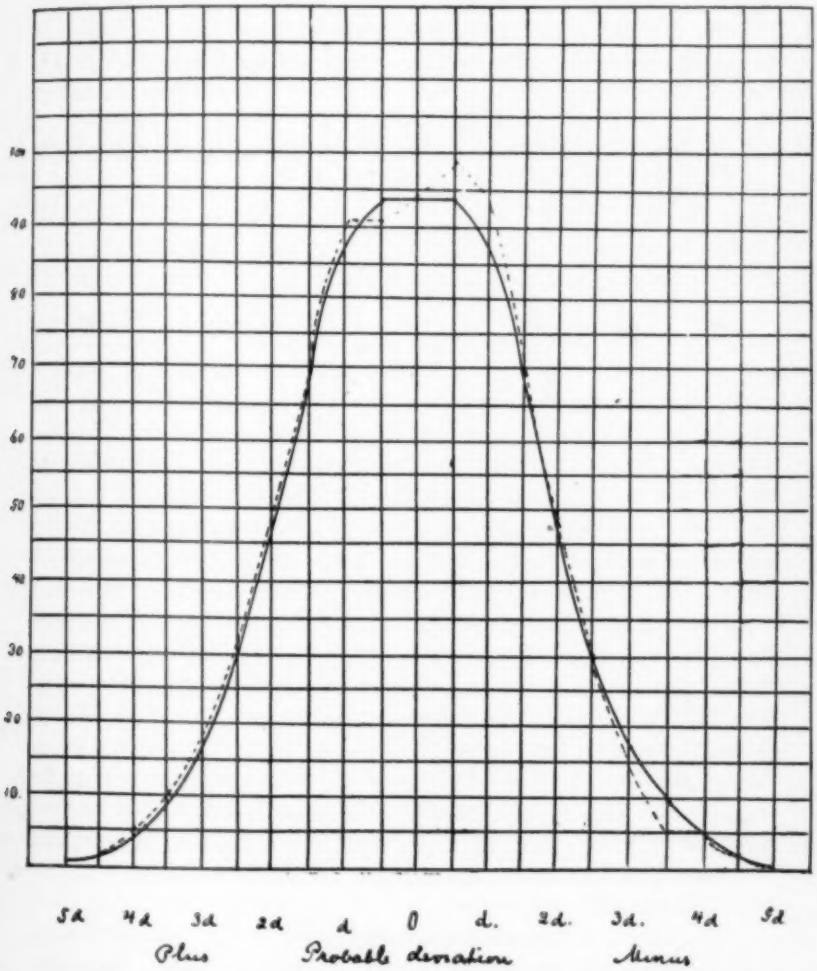
In the preparation of Table IV, Stieda's table, reproduced by Porter, and shown as Table V, has been made use of.

In order to bring out the relation between the theoretical and the observed observations still more clearly, Fig. 1 is appended, which is a graphic representation of Table IV. It is perhaps rather remarkable that the deviations of the observed from the

theoretical curve are greatest about the mean, just where the numbers are largest and where, therefore, the agreement should be expected to be the closest.

FIG. 1.

The Calculated and Observed Distribution of the Height of 722 Naval Cadets aged 17. Unbroken line: according to theory. Broken line: according to observation.



PERCENTILE GRADES.—Another method for calculating the distribution of the observations in a series is the percentile method of Galton. According to this method the distribution of the

observations is determined at intervals of 5 or 10 per cent from the median value.

Table VI shows the percentile distribution of 841 Naval Cadets aged 18 years according to this method.

Perhaps the simplest and, at the same time, the truest means for showing the distribution of, for instance, the height (or any other dimension) in a given series would be to arrange the members according to increasing height at intervals of, say, one-half inch, expressing in numbers the members found between every half inch.

THE PROBABLE ERROR (E) of the average was determined by the formula $E = \pm \frac{d}{\sqrt{n}}$ (Stieda, Porter),

where E = the probable error of average,

d = probable deviation of an individual from the average,

n = number of observations in the series.

Table VII represents the values E as calculated according to this formula.

As was mentioned before, for the sake of uniformity and easy comparison, we have, in the preparation and tabulation of our material, adhered as closely as it was possible to the methods used by Porter. The period of growth covered by our tables is from 15 to 24 years of age, or, practically, to the termination of the growing period, although rare instances have occurred in which growth has been noted to have taken place even later. But such instances as these are extremely rare and can scarcely be called the rule. The tables of both Bowditch and Porter practically stop at the age of 16 years, for males at least, because their numbers after that age are very small and therefore not so reliable as those of the preceding ages. It seemed, therefore, that the material at our disposal might in a way be well calculated to complement theirs, and for this reason, if for no other, it would be very desirable to tabulate it so as to make them both in all respects comparable. We have, accordingly, calculated for every year here represented the average and the mean, the median minus average values, the probable deviations and the probable errors, as well as the 5, 10, 20, 30, 40, 50, 60, 70, 80, 90 and 95 percentile grades. The 25th and 75th percentile grades, given in some of the tables, were obtained by dividing by two the sums of the 30th and 20th and of the 80th and 70th percentile grades respectively.

Averages; Means; Median minus Average Values; Probable Deviations.

These values are shown in Tables VIII, IX, X, and XI, and a brief discussion of them seems now in order.

According to Porter, "the mean or average of the observations at any age in the period of growth is typical of the child at that age, and a comparison of the means at different ages will reveal the law of growth of the type. Again, the mean of the observations at any deviation from the mean of the whole number, for example of the height at a deviation of $+d$ from the mean, or, if Galton's method be employed, the height at any percentile grade, is the type of those who stand at a certain degree of deviation from the type of the whole number. Thus the types of tall and short, light and heavy children are secured. The types of the same degree of deviation from the mean at all ages are as comparable as the type of the whole number of observations, and reveal the growth of the typically tall and short, light and heavy children; but the comparison is less secure the greater the deviation from the mean, for the probable error is inversely as the square of the number of observations, and the number of observations rapidly diminishes on either side of the mean."

This beautiful conception regarding the theory of the growth of tall and short children, however, has been quite recently most severely criticized by Boas in "Science." Boas expresses himself as follows: "We know of a number of facts which show plainly that the assumption is incorrect. It has been shown in Dr. Bowditch's tables that Irish children are shorter than American children. If the position of the American child is expressed in percentile grades of the whole Boston series and that of the Irish child in the same manner, it will be seen at once that they diverge more and more with increasing age. Pagliani's measurements of Italian children and my own of Indian tribes of different statures bring out the same point still more strongly."

Under these circumstances it would seem, perhaps, the safer plan to look upon the averages and the means not as the types themselves, but merely as the indices to the true types.

A mere glance at the tables of the averages and means shows at once that development and growth from year to year is anything but uniform and regular.

The praepubertal acceleration of growth in height, at first fully established by Bowditch and later on confirmed by Kotelmann, Roberts, Erismann and Porter, is also well shown in our tables.

According to Erismann, the period of accelerated growth, beginning with the advent of puberty and ending with the full establishment of sexual maturity, is completed at age 18.

We would add that a period of *retarded* growth follows immediately upon that of accelerated growth, after which period the curve again gradually makes a more rapid ascent towards the completion of the intended height. From age 20 growth is exceedingly slow. This fact is well illustrated in Table XII, in which, for the sake of comparison, I have added my own figures and those given by Porter to a table taken from Erismann.

In all the tables given here the ages have been calculated from the nearest birthday and not from the last birthday. The years, therefore, do not in all cases indicate the absolute age to which these figures belong, on account of the unequal distribution of the numbers within each year, that is to say, as the numbers between 15 and 16 years of age increase there must be a larger number of individuals between 15 and 15½ years than between 14½ and 15 years, so that the average age must be slightly higher than 15. The reverse must be the case, of course, when the numbers begin to decrease.

In connection with our averages and means, the measurements of Gould, taken during the war of secession, of a great many thousands of soldiers of different nationalities, are of some interest. The ages of the soldiers ranged between 31 and 34 years, a time of life when growth in height may most certainly be assumed to have been completed. They are classified as follows:

True Americans,	173.6 cm.
Southern States,	175.0 "
British America,	173.0 "
Englishmen,	170.1 "
Scottish,	171.3 "
Irishmen,	171.1 "
Germans,	169.6 "
French,	169.1 "
Scandinavians,	171.8 "
Spaniards,	168.4 "
Belgians,	168.6 "

Erismann believes that these different nationalities would not have reached this average height in their own native country, and that the different conditions of environment peculiar to this country caused this discrepancy. Topinard puts the average height of Frenchmen at 165.9 cm., and Beddoe places the average height of Englishmen in their own home at 169 cm., while the mean height of Italians, according to Topinard, ranges between 161 and 166 cm.

Roberts, speaking of the most favored classes of English people, in which class he includes naval and military men and university students, puts their average at 175.26 cm.

It was mentioned in the beginning of this paper that Naval Cadets, being appointed from every part of this country, ought to give us as nearly as possible an average that might be considered *national* in character. Now, the average height, as found in our tables of Naval Cadets, is 174.29 cm. at the age of 23, and the mean height is 174.04. If we take the average of what Gould calls true Americans and Americans from the Southern States we obtain 174.30, which is within 1-100 of a centimeter the average height of our Naval Cadets. This agreement of these averages ought to go far in establishing the average height of Americans as at 174.3 cm. when fully developed and of the class which these records cover.

Examining our table of averages a little more closely we find:

1. *Weight.* In weight there is an almost steady increase from the 15th to the 23d year, amounting in all to 37 pounds, the annual increase declining, of course, as age advances.

2. *Height.*—The greatest addition to height standing takes place between 15 and 16 years of age, after which age the annual increase rapidly declines and growth is distinctly retarded about the 18th year, whence again a more marked increase occurs, which comes to a close at the age of 21; a third upward curve leads to the attainment of the final growth.

3. *Height sitting* practically comes to a close at 19 years of age.

4. *Height perineal*, which is the height from the heel up to the perinaeum, closes at about the same age as the preceding.

5. *Circumference of chest* becomes highest at 19, to which it attains at rapidly advancing rates, and thence becomes steady or advancing only by small fractions of an inch.

6. *Lung capacity*, as ascertained by the spirometer, reaches its maximum at 19 and continues steady or varies only slightly.

7. *Waist* shows a continued increase up to the 23d year, remaining, however, stationary from 19 to 21, and after that continues to increase more rapidly.

8. *Span of arms.*—Its greatest increase takes place between 15 and 16 years of age; it then increases slowly but steadily until the 23d year.

9. *Vision.*—We notice here the significant fact that both right and left vision show a positive increase up to the 19th and 20th year. This fact seems of some importance in apparently demonstrating that the course of study at the naval school, and the strain that is necessarily put upon the organ of sight, does not in itself tend towards diminishing the degree of distance vision in an otherwise normally constituted eye, but that, on the contrary, it is rather advantageous in slightly but perceptibly increasing the visual range. The slight decrease in distant vision noticed at the 23d year would indicate to my mind and to those acquainted with life at sea and its requirements on those actively engaged in it, the result of undue strain.

10. *Hearing.*—As to hearing, it is perhaps equally significant that that organ is affected quite perceptibly, but in the contrary direction; we may notice here a gradual but steady decrease for both sides during the entire period under observation, and, no doubt, the occupation of Naval Cadets would lead us to expect just such a result.

11. *Squeeze* shows a steady increase, with but slight and unessential variations.

There exists some difference of opinion as regards the relation of the period of accelerated growth to puberty. If growth and procreation are, as they have been designated, antagonistic processes, we must agree with Bowditch, in that the period of accelerated growth is praepubertal in time. It would perhaps also follow quite naturally that the fullest establishment of maturity should be followed by a period of *retarded growth*, as is apparently shown in our figures of the annual growth. We do not find any great cause for controversy with regard to this question, nor do we consider it difficult to reconcile the opinions held by Bowditch on the one hand and by Pagliani and Carlier on the other. The beginning of the stage of puberty is not necessarily that of sexual maturity. Nature prepares the individual for sexual maturity and

the process of procreation by inaugurating changes that are advantageous to the species and by causing increased development in various dimensions. This sudden wave of normal development completed, it results in sexual maturity becoming fully established and functional, and with its full establishment, growth in the different dimensions takes a short and much-needed rest, during which the organism at large sympathetically accommodates itself to the new order of things.

It is more than merely probable that the exact time of life when this praepubertal development begins is, within a certain limited range, different for every individual even of the same type and social class. In some it may come on a little sooner, in others a little later, so that these two phenomena must neutralize each other to a certain extent by this overlapping, and the probable result must be that the absolute praepubertal increase is actually larger than it is usually recorded.

Neither the average nor the mean gives us any information as regards the manner in which the individual measurements of a series are distributed, and it is clear that two series with an identical mean or average may yet differ largely in respect of the dispersion of the individuals from the middle value, as was shown above.

According to Boas, the mean deviation is the more accurate of the two, and which is no doubt true; but inasmuch as its relation to the probable deviation would be in all respects constant, and as it was one of our objects to make the results of our investigations comparable to those of previous investigators, the preference was given to the probable deviation.

Table VIII represents the probable deviations for the items that were available for calculation. It will be seen by this table that they are small, even when compared with those given in Porter's tables, which indicates that one-half of all the observations deviate but little from the middle values, and which fact is considered to be one of the fundamental attributes of all deviations due to accidental causes.

It is extremely doubtful from present appearances whether any further significance will ever be attached to the percentile grade system in the future than that of using it merely as a means for classifying anthropometric facts in percentages.

Boas, in his latest contribution to "Science," March, 1895,

states that if the assumption is made that the same children remain on the average in the same percentile grades, a certain very complex law must follow; for any different law of growth, children would change from one grade to another. And Porter remarks that in order to determine the relation of the growth of the individual to the growth of the type we must have material that admits of the application of the individualizing method, and that the present state of our knowledge of the subject does not permit us the prediction of future growth.

I believe that the prediction of future growth, even after having accumulated a sufficient amount of material which will permit of the application of the individualizing method, will always form a difficult if not doubtful task, for the reason that we are unable to predict, at the same time, the causes that will influence individual growth.

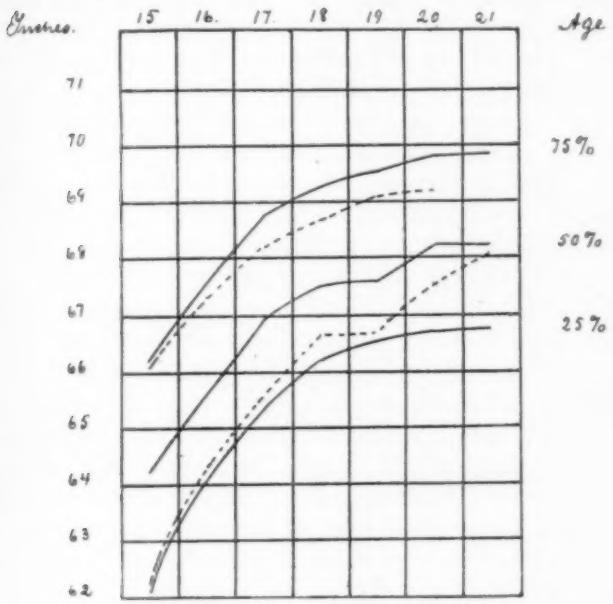
In the records at my disposal I find that their continuity is often broken by the omission of one or more items for one or more years in succession. This may be due to an oversight on the part of the examiner, or to a temporary inability on the part of the examinee to submit to that part of the examination. Hence if a very large number of such continuous individual records were required, even the material at my disposal would not be such as to definitely settle this question practically; and if I were to rely on broken records and put a larger number of these together and average them, I would simply arrive at about the same curves that are presented as the results of the whole number of observations. In fact, our averages and means and the deviations therefrom are the results of just such records, about 30 per cent of them being continuous and, with the exceptions mentioned, unbroken for the period of growth covered by them.

However, on searching these records I was able to find between 35 and 40 continuous records of individual cadets, each beginning with the 25th percentile grade in height as well as in weight, either at 15 or 16 years of age, and as many such as began with the 75th percentile grade in the same items and at the same ages. These, when examined individually and compared to the average progression of their respective percentile grades obtained from the whole number of observations that are recorded here, revealed the fact that not a single one of them remained in the grade to which it belonged.

The exact number of individual records belonging to the 25 percentile grade as to weight is 40, and that of those belonging to the 75th percentile grade is 36. As to height standing, there were 39 belonging to the 75th and 37 belonging to the 25th percentile grade.

FIG. 2.

Height.—Percentile and Individual Curves Compared.



Continuous lines: normal, 75, 50 and 25 per cent.
Broken lines: individual, 75 and 25 per cent.

The averages of these records have been tabulated together with the 25th, 50th and 75th percentile grades obtained from the whole number of observations, viz. Table XIII.

The relation which these individual averages bear to the general averages is best seen in Figs. 2 and 3 plotted from the tables.

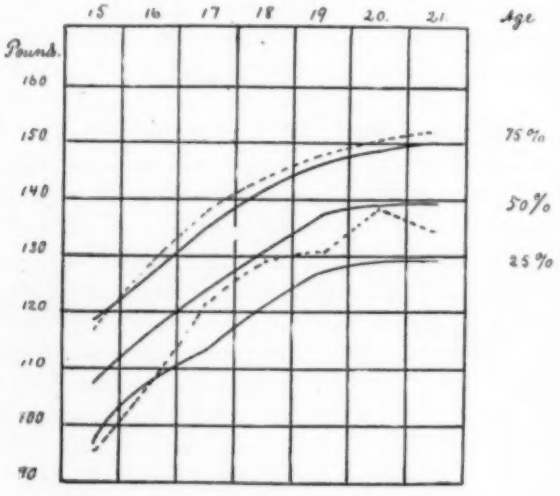
The 25th percentile individual curve of both height and weight shows a marked tendency to approach the 50th percentile grade curve or the mean of all the observations. As to height alone, the 75th percentile individual curve likewise, but not so directly as the 25th percentile curve, inclines toward the curve of the

middle value. In both the height-curves there is, it would seem, *a strong aim at the middle value towards the end of the period of growth.*

The curves, shown in Fig. 2, and a detailed comparison of the individual records with the normal percentile grades of their class, *would go far in convincing me of the fact that individuals do not necessarily remain in the percentile grades in which, at some time during their period of growth, they may happen to be found.*

FIG. 3.

Weight.—Percentile and Individual Curves Compared.



Continuous lines: normal, 75, 50 and 25 per cent.
Broken lines: individual, 75 and 25 per cent.

As, however, this question seems to be one of the greatest importance, and inasmuch as a definite settlement of all doubts in regard to this matter would be looked upon as a positive advance of our ideas of growth, we have attempted to enter a little more into the details of the matter.

We began by making a somewhat larger collection of individual and continuous records. By allowing a broader limit than a certain percentile grade to begin with, we have succeeded in accumulating the data exhibited in the three Tables XIV, XV and XVI, and have divided them into three groups for reasons

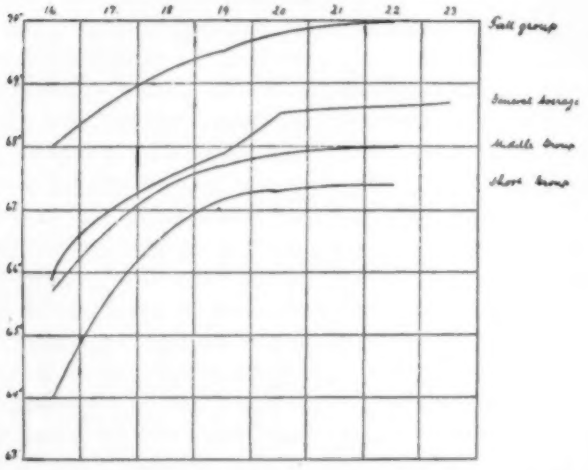
which will become more apparent as we proceed. It was perhaps to be expected that growth for tall boys would be found to be different from what it is for short ones, and these tables seem to prove this suspicion to be absolutely correct. When the averages given in these three tables are compared it becomes very evident that there is a well characterized law of growth for each of the three groups, that is to say, it is seen that the short boys grow more rapidly than the tall boys and also more rapidly than middle-sized boys during the period under consideration. Thus we find that the short boys grow 4.2 inches, the middle-sized ones 3.3 inches, and the tall ones only 2.0 inches during a period from 16 to 22 years of age. Previous conditions may perhaps often determine the growth that follows, and the smaller a boy at a certain age during the period of growth the greater will be his chances for growing during the years that follow, while tall boys are very much more apt to have their growth completed earlier than small boys are. Still it seems we cannot deny that present environments and causes also continue to exert an unmistakable influence on growth no matter what the preceding ones may have been.

In order to bring out the difference in the growth of the several groups still more clearly we have made certain selections from the larger tables between definite limits, and have calculated the averages and the probable deviations from different years. The selection was made at every year between the limits indicated on the tables, and then the number of individuals thus selected was carried straight through to the twenty-second year, as shown in Table XVII. It will be noticed by a glance at the table (XVII) that while the averages increase from beginning to end as well as from above downwards during the same years or in the direction from the lowest to highest average, the probable deviations increase only from year to year; but when read from above downwards they very rapidly decrease. In the tall group the averages increase but slightly from year to year in each group and from within the limits indicated; but when read from above downwards they tend to decrease in spite of the limits from which they were started growing steadily higher. The limit of this decrease, however, is soon reached and the averages increase correspondingly. The reason for this behavior in the averages is that the number of those that cease growing increases rapidly and consequently drop out of the succeeding series which contains naturally the tallest and the fewest.

The probable deviations always show a rapid increase between the first two years of every new series; they regularly decrease from above downwards and approach more nearly the average.

FIG. 4.

Annual Growth of Average of whole number of obs. compared with that of three selected individual groups.



This increase in the probable deviation between the first two years or at the beginning of each series is, no doubt, due to the rapid scattering of the members in each series, and plainly shows that they do not retain the same relation to each other in the next series in which they were contained in the preceding series, and which is additional proof of the fact that *percentile grades do not control growth.*

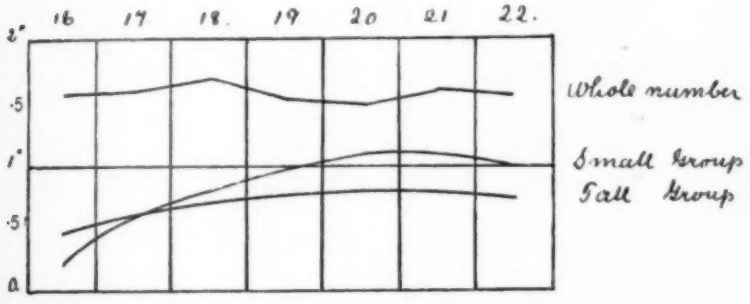
The average values, showing the absolute annual increase, are not necessarily the most frequent values, as is well known, and consequently we must find out something of the individual growth and their numerical proportion and distribution which produce this average.

For this purpose we have calculated the individual growth between two successive years from our original Tables XIV, XV and XVI and tabulated the results represented in Table XVIII. This table of the individual absolute annual increases in height shows at once the distribution of growth, the most frequent

values, and also, in a very striking manner, the number of those who cease to grow and at what age. The difference in the growth between tall and short boys is here brought out very strongly. The figures show as clearly as one could wish that tall boys are much more likely to have completed their growth at an earlier age than short boys, and also that short boys not only grow more rapidly and more extensively than tall boys, but also that they continue to grow up to a later age than do tall boys.

The rapidly increasing numbers at zero, to be seen on Table XVIII, prove conclusively that tall boys have completed their adult stage of development in height at an earlier age than short ones.

FIG. 5.



In perfect agreement with this conclusion would seem to be the probable deviation as shown in Fig. 5. In small boys this deviation is seen to rise much higher than in tall ones.

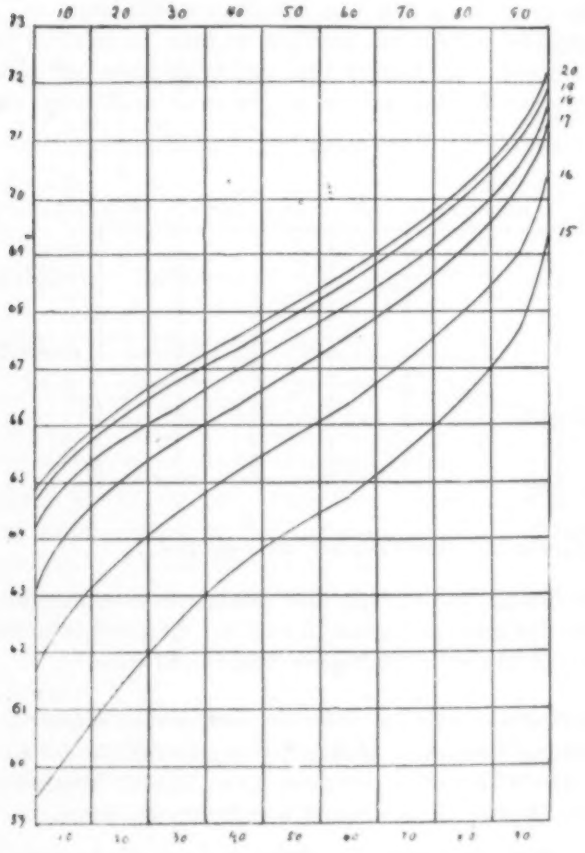
PERCENTILE GRADES IN HEIGHT STANDING, WEIGHT, HEIGHT SITTING, PERINEAL HEIGHT, CIRCUMFERENCE OF CHEST, LUNG CAPACITY, SPAN OF ARMS, WAIST MEASURE, AND RIGHT AND LEFT HAND SQUEEZE.

The percentile grades in these various dimensions are presented in Tables XIX-XXVIII, and those of height standing and weight are also graphically represented in Figs. 6 and 7 respectively. With the help of these tables and plates the percentile rank of any individual in any of the above-mentioned dimensions may be easily and quickly determined.

Supposing, for instance, the percentile rank of a cadet aged 17 years and weighing 134 pounds was desired. A horizontal line is drawn from 134 in the column of weights on the left of the plate to the curve of age 17, and a perpendicular is dropped from the

FIG. 6.

Heights of Naval Cadets.—Percentile Grades.



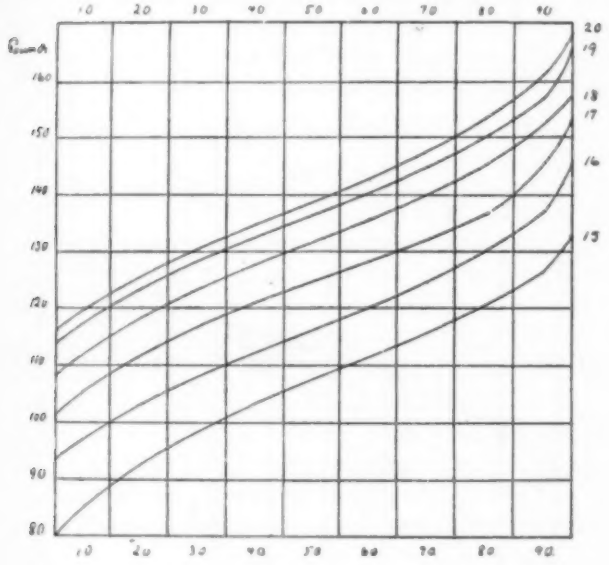
point of intersection to the scale of percentile grades at the bottom of the plate. The perpendicular falls at 75 per cent, and hence the cadet in question is heavier than 75 per cent of the cadets of his age and lighter than the remaining 25 per cent.

Likewise we may find the increase at any percentile grade dur-

ing one or more years by measuring the distance between the curves at that grade and comparing that distance with the pound scale, which will give the number of pounds. In the same plate the gain in weight of the 50 percentile grade cadet during the years of 15 and 18 is 24 pounds, and the gain in weight of the 80th percentile grade cadet during the same period is found to be 25 pounds.

FIG. 7.

Weight of Naval Cadets.—Percentile Grades.



In a somewhat similar manner the percentile rank of any cadet at any age in any dimension included in our tables may be found by a reference to these tables. Their value, therefore, as an aid to the annual examiner of cadets may easily be estimated.

RATE OF GROWTH.

The ten tables XXIX-XXXVIII represent in percentile grades the absolute annual increase in the various dimensions as calculated from the whole number of observations and without regard to whether they are large or small. By absolute annual increase is meant the gain in height or weight during the preced-

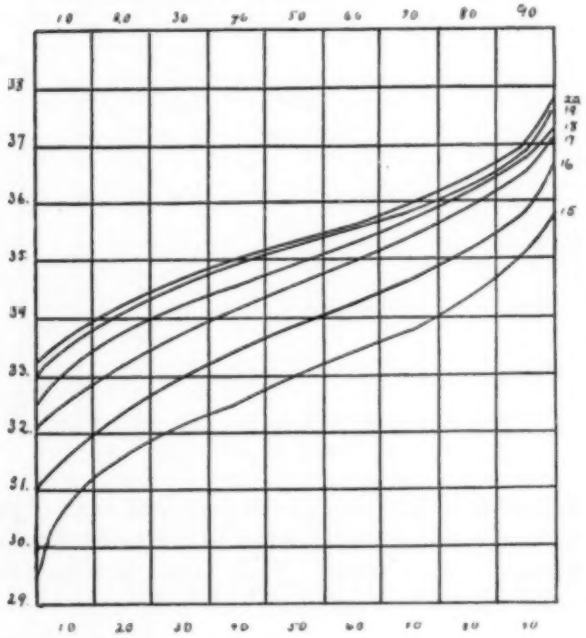
ing twelve months, obtained by subtracting the average or median height or weight at, for instance, 18 from that at 19 years.

On account of the unequal distribution of the numbers between the different years, the ages given in the column are not absolutely correct, but the error is so small that it may be neglected here.

It will be noticed that the rate of increase in the various dimensions differs considerably. The subject of the correlation of the different dimensions to one another at the different ages and in individuals of different statures is still to be determined. To settle this question we need a large number of individual records.

FIG. 8.

Perineal Height of Naval Cadets.—Percentile Grades.



As regards weight, we notice a steady decrease in the annual amount of gain from the 15th to the 21st year, which decrease becomes most marked from the 19th year on upwards, and in the highest percentile grades is even negative.

Height once attained is not so easily lost, but weight is easily lost as well as quickly regained.

As to height, the greatest annual increase is noticed to take place between 15 and 16 years of age, the lowest between 18 and 19 years. In some of the highest percentile grades it apparently becomes slightly negative as it does in the weight tables; this is more especially shown between the 21st and 22d years, but also noticeable between the 20th and 21st years. The reason for this negative annual increase is well explained by our Tables XIV, XV and XVI, which show clearly that just about the 21st year our averages are less reliable than they are at other ages, and therefore our annual growth tables do not in the least render improbable the fact that height once attained is rarely if ever lost.

Weight and strength, on the other hand, are easily lost and rapidly regained, and any decrease in these may therefore be easily explained.

Relative Annual Increase.

The ten tables XXXIX-XLVIII represent in percentile grades the relative annual growth in the different dimensions under discussion. Relative annual increase means the increase for any year divided by the average at that year. Thus the relative annual increase in weight at age 18 is the difference between the average weight at 17 and 18 divided by the average weight at 17.

According to Porter (loc. cit.) the relative annual increase gives a truer idea of growth than does the absolute annual increase, because of the latter being entangled with the size of the individual measured. Porter also states that "the absolute annual increase is commonly greater in a big boy than in a small boy,and yet the rate of growth may be the same." This is no doubt true for that period of growth which is covered by the material worked out by him. For a later period, from 15 to 22 years, the rate of growth for big boys is both absolutely and relatively smaller than for short boys. This is not only well shown in our percentile height-curves on Fig. 6, plotted from the whole number of our observations, but also in our individual Tables XIV, XV and XVI, as well as in Fig. 4.

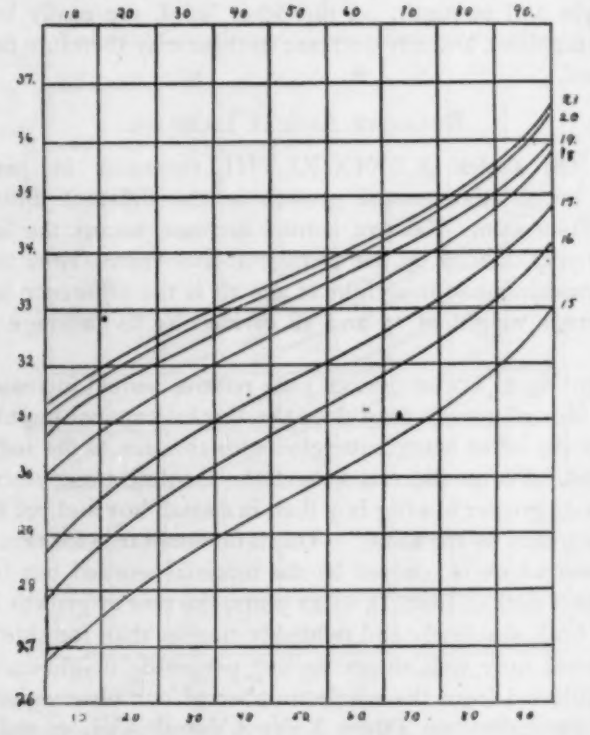
So far as weight is concerned these tables show the same gradual decrease in the annual rate as the height tables. This decrease is here most abruptly marked between 19 and 20, becoming negative with the 21st year.

Tables XLIX-LVIII.

The material here presented would admit of still further elaboration. The dimensions of correlated parts and their ratios to one another ought to be worked out. The difficulty, however, that presents itself here is the same that was encountered in connection with the rate of growth and its difference between tall and short boys. The facts so far would indicate that, for instance, the ratio that exists between growth in height and chest girth is differ-

Fig. 9.

Chest Girth of Naval Cadets.—Percentile Grades.



ent for short boys from what it is for tall boys. This work must be done on material admitting of the application of the individualizing method and separately for small, middle-sized and tall individuals, to be of value and conclusive.

The tables XLIX-LVIII, however, will prove useful, admitting, as they do, of ready reference and comparison and containing a great deal of information in a small space.

APPENDIX.

TABLE I.

The observed distribution of the Heights of 842 Naval Cadets aged 18 yrs

Heights at intervals of one inch.	Number of Observations.
73–76	1
74–75	2
73–74	5
72–73	23
71–72	38
70–71	80
69–70	118
68–69	135
67–68	146
66–67	135
65–66	94
64–65	38
63–64	15
62–63	8
61–62	3
60–61	
59–60	1
Total..	842

TABLE II.

The calculation of the Average Hand-Squeeze (right) of 225 Naval Cadets aged 17 years.

Strength in Pounds.	Number of Observations. (n)	Product (a)
50	2	100
55	3	165
60	15	900
65	18	1170
70	30	2100
75	43	3225
80	40	3200
85	34	2810
90	20	1800
95	11	1045
100	6	600
105	3	315
Total..	$n = 225$	$\Sigma a = 17430$

$$A = \frac{\Sigma a}{n} = \frac{17430}{225} = 75.46 \text{ pounds.}$$

TABLE III.

The calculation of the Probable Deviation (d) from the average weight (125 lbs.) of 722 Naval Cadets aged 17 years.

Weight at intervals of five pounds.	n No. observed.	δ Deviation.	$n\delta$
195–200	1	75	75
170–175	2	50	100
165–170	2	45	90
160–165	6	40	240
155–160	11	35	385
150–155	19	30	570
145–150	24	25	600
140–145	51	20	1020
135–140	59	15	885
130–135	85	10	850
125–130	97	5	485
120–125	97	0	
115–120	82	5	410
110–115	71	10	710
105–110	61	15	915
100–105	35	20	700
95–100	7	25	175
90– 95	9	30	270
85– 90	2	35	70
80– 85	1	40	40
	722		8490

$$d = \pm 0.8453 \frac{8490}{722} = \pm 9.94.$$

TABLE IV.

The theoretical and observed distribution of the Heights of 722 Naval Cadets aged 17 years.

Probable Deviation.	Height at intervals of $\pm 0.5d$.	Theoretical Distribution.	Observed Distribution.
+ 5.0 d	73.00	1	1
+ 4.5 "	74.20	2	2
+ 4.0 "	73.40	4	5
+ 3.5 "	72.60	9	11
+ 3.0 "	71.80	17	18
+ 2.5 "	71.03	30	32
+ 2.0 "	70.20	48	46
+ 1.5 "	69.40	69	70
+ 1.0 "	68.60	87	90
+ 0.5 "	67.80	94	91
0.0 "	67.00		
− 0.5 "	66.20	94	99
− 1.0 "	65.40	87	94
− 1.5 "	64.60	69	72
− 2.0 "	63.80	48	48
− 2.5 "	62.97	30	14
− 3.0 "	62.20	17	16
− 3.5 "	61.40	9	5
− 4.0 "	60.60	4	5
− 4.5 "	59.80	2	2
− 5.0 "	59.00	1	1
	Total..	722	722

TABLE V.

Stieda's Table for calculating the number of observations at any distance from the mean or average within the limits: $M + sd$ and $M - sd$.

p.	%	p.	%
0.1	5.4	1.8	77.5
0.2	10.7	1.9	80.0
0.3	16.0	2.0	82.3
0.4	21.3	2.1	84.3
0.5	26.4	2.2	86.2
0.6	31.4	2.3	87.9
0.7	36.3	2.4	89.5
0.8	41.1	2.5	90.8
0.9	45.6	2.6	92.1
1.0	50.0	2.7	93.1
1.1	54.2	2.8	94.1
1.2	58.2	2.9	95.0
1.3	61.9	3.0	95.7
1.4	65.5	3.5	98.2
1.5	68.8	4.0	99.3
1.6	71.9	4.5	99.8
1.7	74.8	5.0	99.93

TABLE VI.

The percentile distribution of the Heights of 842 Naval Cadets aged 18 years, according to this method.

Percentile Grades.	Heights.
5	64.56
10	65.00
20	65.50
30	66.70
40	67.01
50	67.66
60	68.54
70	69.00
80	69.58
90	70.55
95	71.52

TABLE VII.

Probable Error of Average: $E = \pm \frac{d}{\sqrt{n}}$, where e = probable error, d = probable deviation, n = number of observations.

Dimensions.	Unit of Measurement.	Age at nearest Birthday and Probable Error.								
		15	16	17	18	19	20	21	22	23
Weight, (nude)	pounds.	0.922	0.531	0.370	0.400	0.360	0.371	0.456	0.500	0.768
Height, standing	inches.	0.136	0.080	0.059	0.057	0.054	0.060	0.071	0.086	0.099
Height, sitting	inches.	0.088	0.048	0.032	0.027	0.035	0.027	0.024	0.040	0.036
Height, perineal	inches.	0.131	0.074	0.045	0.040	0.031	0.038	0.070	0.062	0.073
Chest circumference	inches.	0.123	0.066	0.044	0.043	0.038	0.048	0.052	0.065	0.079
Lung capacity	cb. inches.	2.306	1.091	0.820	0.782	0.642	0.834	0.940	1.150	1.125
Waist circumference	inches.	0.095	0.052	0.042	0.044	0.044	0.052	0.062	0.070	0.093
Span of Arms	inches.	0.130	0.091	0.064	0.060	0.062	0.078	0.076	0.108	0.093
Vision, R. E.	feet.	0.270		0.103	0.108	0.120	0.163	0.163	0.163	0.243
Vision, L. E.	feet.	0.231	0.132	0.111	0.102	0.115	0.133	0.127	0.172	0.233
Hearing, R. Ear	feet.		0.069	0.050	0.038	0.054	0.100	0.076	0.247	0.238
Hearing, L. Ear	feet.			0.036	0.036	0.027	0.073	0.110	0.210	0.234
Squeeze, R. H.	pounds.	0.800	0.367	0.273	0.245	0.274	0.316	0.365	0.449	0.421
Squeeze, L. H.	pounds.	0.790	0.367	0.274	0.250	0.278	0.322	0.327	0.463	0.466

TABLE VIII.

Probable Deviation (d') from the average: $d' = \pm 0.8453 \frac{\Sigma \delta}{n}$, where δ = Deviation of average, $\Sigma \delta$ = Sum of individual deviations, n = Total number of observations.

Dimensions.	Unit of Measure.	Age at nearest Birthday and Probable Deviation.								
		15	16	17	18	19	20	21	22	23
Weight	kilos.	4.808	4.790	4.508	5.116	4.472	4.277	4.599	4.114	5.357
	pounds.	10.6	10.56	9.94	11.28	9.86	9.43	10.14	9.07	11.81
Height, standing	c. m.	4.97	3.96	4.03	4.20	3.81	3.81	4.01	3.96	3.83
	inches.	1.96	1.56	1.59	1.68	1.50	1.50	1.58	1.56	1.51
Height, sitting	c. m.	2.56	2.43	2.18	2.05	2.49	1.77	1.37	1.88	1.44
	inches.	1.01	0.96	0.86	0.81	0.98	0.70	0.54	0.74	0.57
Height, perineal	c. m.	3.83	3.27	3.17	3.09	2.18	2.49	4.24	2.89	2.84
	inches.	1.51	1.29	1.23	1.22	0.86	0.98	1.67	1.14	1.12
Circumference Chest	c. m.	3.60	3.37	3.18	3.20	2.64	3.09	2.94	2.99	3.04
	inches.	1.42	1.33	1.23	1.26	1.04	1.22	1.16	1.18	1.20
Lung capacity	cb. c. m.	427.	355.	360.	373.	320.	376.	330.	330.	312.
	cb. inches.	26.1	21.69	22.0	22.87	19.6	21.19	20.84	20.83	19.05
Circumference Waist	c. m.	2.76	2.61	2.87	3.30	3.07	3.37	3.50	3.23	3.60
	inches.	1.09	1.03	1.13	1.30	1.21	1.33	1.38	1.28	1.42
Span of Arms	c. m.	2.99	4.59	4.41	4.44	4.36	4.69	4.26	5.02	3.60
	inches.	1.18	1.81	1.74	1.75	1.72	1.85	1.68	1.98	1.42
Vision, R. E.	meter.	.917	.183	.847	.936	1.002	1.201	1.106	.927	1.130
	feet.	3.09	0.6	2.78	3.14	3.29	4.14	3.63	2.95	3.71
Vision, L. E	meter.	.811	.799	.914	.950	.980	1.029	.857	.947	1.081
	feet.	2.66	2.62	3.0	3.12	3.21	3.38	2.81	3.12	3.55
Hearing, R. Ear	meter.		.420	.411	.515	.463	.771	.515	1.365	1.106
	feet.	0.0	1.38	1.35	1.69	1.52	2.53	1.69	4.48	3.63
Hearing, L. Ear	meter.			.298	.317	.231	.564	.741	1.161	1.181
	feet.	0 0	0.0	0.98	1.04	0.76	1.85	2.43	3.81	3.88
Squeeze, R. H.	kilos.	4.136	3.311	3.325	3.225	3.411	3.643	3.677	3.681	2.912
	pounds.	9.12	7.30	7.33	7.11	7.52	8.03	8.11	8.14	6.42
Squeeze, L. H.	kilos.	4.136	3.316	3.370	3.273	3.370	3.715	3.293	3.810	3.210
	pounds.	9.06	7.31	7.43	7.22	7.43	8.19	7.26	8.40	7.10

TABLE IX.

Values of the Averages in the following dimensions.

Age at nearest Birthday.	No. of Observations.	Weight in kilos., pounds.	Height, standing, c.m., inches.	Height, sitting, c.m., inches.	Height, perineal, c.m., inches.	Circumference of Chest, c.m., inches.	Lung capacity, litres, cb. inch.	Waist, c.m., inches.	Span of Arms, c.m., inches.	Vision, R. E. metres, feet.	Vision, L. E. metres, feet.	Hearing, R. Ear. metres, feet.	Hearing, L. Ear. metres, feet.	Squeeze. R. H. kilos, lbs.	Squeeze. L. H. kilos, lbs.
		48.53	169.052	84.58	81.28	77.47	2.998	63.75	169.30	7.314	7.314	12.192	12.192	27.66	27.21
15	132	107.	63.8	33.3	32.0	30.5	183	25.09	63.9	24.0	24.0	40.0	40.0	61.0	60.
		53.01	167.456	86.48	83.82	80.51	3.293	66.04	170.94	7.332	7.559	11.978	12.192	32.43	31.75
16	395	118.	65.93	34.5	33.2	31.67	201	26.0	67.33	24.6	24.8	39.3	40.0	71.5	70.
		56.70	170.30	88.90	86.36	82.55	3.555	69.59	172.72	7.742	7.620	11.887	12.009	35.127	34.74
17	722	125.	67.05	35.0	34.0	32.5	217	27.36	68.0	25.4	25.0	39.0	39.4	77.47	76.6
		60.55	170.710	90.79	87.36	85.09	3.709	70.80	175.84	7.711	7.528	11.826	11 978	36.74	36.28
18	841	133.4	67.29	35.75	34.6	33.46	226	27.9	69.25	25.3	24.7	38.8	39.3	81.0	80.
		63.36	172.466	91.56	91.8	88.90	3.932	72.61	178.05	7.711	7.681	11.887	12.039	38.55	37.64
19	750	139.7	67.90	36.50	35.9	35.0	240	28.6	70.12	25.3	25.24	39.0	39.5	85.0	83.
		64.05	174.117	89.10	88.90	87.12	3.915	72.64	178.05	7.345	7.925	11.643	11.826	39.46	38.55
20	643	141.2	68.55	35.77	35.0	34.3	239	28.62	70.1	24.1	26.0	38.2	38.8	87.0	85.
		63.40	174.224	91.44	86.36	87.12	3.948	72.89	179.83	7.437	7.620	11.887	11.582	39.91	39.64
21	493	140.	68.6	36.0	34.0	34.3	241	28.68	70.67	24.38	25.0	39.0	38.0	88.0	87.4
		64.09	173.863	91.44	88.90	87.20	4.030	73.15	178.30	7.498	7.406	11.217	11.338	39.23	38.91
22	328	141.3	68.45	36.0	35.0	34.35	246	28.8	70.2	24.6	24.34	36.8	37.2	86.5	85.8
		65.31	174.294	91.44	88.90	88.39	3.964	74.16	180.34	6.888	7.010	11.427	11.368	39.28	38.42
23	232	144.0	68.62	36.0	35.0	34.8	242	29.2	71.0	22.6	23.0	37.5	37.3	86.6	84.7

TABLE X.

Median Values in same dimensions as Table IX.

Age at nearest Birthday.	No. of Observations.	Weight.	Height, standing.	Height, sitting.	Height, perineal.	Circumference of Chest.	Lung capacity.	Waist Circumference.	Span of Arms.	Squeeze, R. H.	Squeeze, L. H.
		49.216	163.29		84.12	76.07	2.920	63.70	163.83	27.21	25.58
15	131	108.5	64.290		33.125	29.952	178.2	25.12	64.50	60.0	56.4
		53.025	167.13	85.34	85.92	78.99	3.170	65.45	169.67	30.84	29.48
16	305	116.9	65.805	33.500	33.830	31.101	193.5	25.77	66.80	68.0	65.
		56.610	170.18	86.81	87.88	81.25	3.421	67.18	172.46	34.10	33.33
17	722	124.8	67.000	34.180	34.600	31.895	208.8	26.45	67.90	75.2	73.5
		59.780	171.78	87.96	88.90	83.00	3.588	69.13	174.11	35.14	34.01
18	841	131.8	67.633	34.630	35.007	32.685	219.0	27.22	68.55	77.5	75.0
		62.14	171.83	89.07	89.50	84.45	3.736	70.10	175.33	37.19	36.96
19	750	137.0	67.651	35.055	35.243	33.250	228.3	27.60	69.03	82.0	81.5
		62.823	173.35	89.53	89.68	85.29	3.818	71.06	176.27	38.00	37.19
20	645	138.5	68.252	35.254	36.310	33.588	233.2	27.98	69.40	83.8	82.0
		63.004	173.25	90.01	89.76	85.47	3.801	70.33	177.62	38.91	38.32
21	493	138.9	68.215	35.445	35.340	33.656	232.2	27.69	69.93	85.8	84.5
		62.914	173.60	89.71	90.14	85.77	3.883	70.63	176.78	38.55	38.00
22	328	138.7	68.352	35.320	35.492	33.776	237.9	27.81	69.60	85.0	83.8
		62 732	174.04	89.73	90.55	86.28	3.872	70.84	174.62	40.37	38.55
23	232	138.3	68.522	35.333	35.634	33.873	236.3	27.89	69.93	89.0	85.0

TABLE XI.

Median minus Average Values.

Dimensions.	Unit of Measurement.	Ages at nearest Birthday and Median minus Average Values.								
		15	16	17	18	19	20	21	22	23
Weight	pounds.	+ 1.5	— 1.1	— 0.2	— 1.5	— 2.7	— 2.7	— 1.1	— 2.6	— 5.7
Height, standing	inches.	+ 0.490	— 0.125	— 0.05	+ 0.343	— 0.249	— 0.298	— 0.385	— 0.098	— 0.098
Height, sitting	inches.		— 1.000	— 0.820	— 1.120	— 1.445	— 0.516	— 0.555	— 0.680	— 0.667
Height, perineal	inches.	+ 1.125	+ 0.630	+ 0.600	+ 0.407	— 0.657	+ 0.310	+ 1.340	+ 0.492	+ 0.645
Chest circumference	cb. inches.	— 0.548	— 0.569	— 0.605	— 0.775	— 1.756	— 0.712	— 0.644	— 0.574	— 0.927
Lung capacity	cb. inches.	— 4.8	— 7.5	— 8.2	— 7.0	— 11.7	— 5.8	— 8.8	— 8.1	— 5.7
Waist circumference	inches.	+ 0.03	— 0.23	— 0.97	— 0.68	— 1.00	— 0.64	— 0.09	— 0.99	— 1.31
Span of Arms	inches.	+ 0.60	— 0.53	— 0.10	— 0.70	— 1.09	— 0.70	— 0.74	— 0.60	— 1.07
Squeeze, R. H	pounds.	— 1.0	— 3.5	— 2.27	— 3.5	— 3.0	— 3.2	— 2.2	— 1.5	+ 2.4
Squeeze, L. H	pounds.	— 3.6	— 5.0	— 3.1	— 5.0	— 1.5	— 3.0	— 2.9	— 2.0	+ 0.3

TABLE XII.

Showing Annual Growth of different Nationalities.

Ages.	Beyer, c. m.	Bowditch, c. m.	Kotelmann, c. m.	Roberts, c. m.	Erismann, c. m.	Porter, c. m.	
						Av.	Mean.
13–14		6.80	5.79	5.4	3.48	5.67	5.57
14–15	2.54	6.10	5.31	5.1	5.45	6.32	6.39
15–16	5.41	6.90	7.46	5.6	6.53	5.37	6.02
16–17	2.84	2.10	5.25	6.7	5.38	4.86	4.73
17–18	0.60	1.60	1.49	3.9	3.19	5.28	4.50
18–19	1.54	1.40		1.9	1.80		
19–20	1.90			1.8	0.80		
20–21	.12						
21–22	.38						
22–23	.43						

TABLE XIII.

Comparison of Normal* with Individual Records.

I.—Height.

Percentile Grades.	Ages at nearest Birthday.						
	15	16	17	18	19	20	21†
Normal 75	66.20	67.61	68.70	69.29	69.52	69.86	69.83
Individual 75	66.10	67.45	68.25	68.76	69.10	69.15	69.80
Normal 50	64.29	65.85	67.00	67.63	67.63	68.25	68.21
Individual 25	62.20	64.44	65.62	66.70	66.65	67.62	68.07
Normal 25	62.05	64.14	65.50	66.18	66.54	66.75	68.74

II.—Weight.

Individual 75	117.0	129.3	138.0	144.0	148.0	150.0	152.0
Normal 75	118.5	127.8	135.0	143.0	147.5	149.6	149.9
Normal 50	103.5	116.9	124.8	131.8	137.0	138.5	138.9
Individual 25	95.5	107.5	122.0	130.0	130.3	137.0	134.4
Normal 25	95.9	106.2	114.4	121.9	127.1	128.	129.3

* Number smaller than under the preceding years, especially in individual 75 percentile grade, and therefore this grade is not plotted.

† Refers to the averages derived from the whole number of observations, expressed here in percentile grades.

TABLE XIV.

Individual and Continuous Measurements in Height, Standing. Tallest Group.

No.	Inches at the following years. 16	17	18	19	20	21	22
1	68.4	70.0	70.5	71.0	71.1		71.0
2	68.0	69.3	69.5	69.5	69.5		69.6
3	67.4	68.0	68.6	68.3	68.3		68.3
4	69.0	69.7	70.4	70.4	70.5		70 5
5	68.0	68.5	68.7	69.3	69.4		
6	67.4	68.0	68.2	68.3	68.3		68.5
7	68.2	68.6	68.7	69.0	69.1		69.1
8	68.5	69 2	69.3	69.5		69.7	
9	68.5	69.2	69.4	69.2	69.2		69.5
10	67.2	67.6	68.0	68.0	68.1		68.0
11	67.2	67.2	67.5	68.0			
12	68.0	68.6	69.0	69.1	69.2		69.3
13		68.0	68.4	68.6	68.7	68.7	68.7
14		66.7	67.1	67.4	67.4	67.4	67.4
15	67.2	68.3	69.3	69.5	69.6	70.1	70.2
16	68.2	68.6	69.0	69.2	69.4		69.4
17	69.0	70.2	71.0	71.3	71.5		71.4
18	68.7	69.3	69.7	69.7	69.7		69.7
19	67.2	68.1	68.1	68.3	68.2		68.4
20		67.0	67.2	67.5	67.7		67.6
21	68.6	69.4	69.4	70.0	70.1		70.1
22	69.0	69.2	69.2	69.2	69.2		69.2
23	67.0	68.1	68.5	68.7	69.0		69.1
24		66.3	69.4	70.1	70.4	70.4	70.5
25	68.2	69.4	71.0	71.4			71.4
26	67.7	68.1	68.2	68.3		68.4	
27	69.4	70.4	71.2	71.2	71.5		71.6
28	67.4	68.4	68.4	69.0	69.4		70.0
29	68.2	69.4	70.2	71.2	71.2		71.2
30	69.0	69.0	69.0	69.0	69.5		69.4
31	67.0	68.3	68.7	69.0	69.1		69.1
32	67.0	68.0	68.6	68.6	69.0		69.2
33	67.2	67.4	68.0	68.6	68.6		68.6
34	68.3	69.5	70.7	71.1	71.2		71.2
35	69.2	69.3	69.7	70.2	70.4		70.4
36	68.0	68.5	69.0	69.0	69.0		69.1
37	67.0			72.4	73.4	73.4	73.2
38	68.5	69.2	69.2	69.4	69.7	70.0	70.1
39	68.0	69.5	71.0	72.0	72.1		
40	67.4	68.1	68.4	68.4	68.6		68.6
41	68.6	70.3	70.5	71.4	72.2		72.4
42	68.5	69.4	69.4	69.4	69.6		70.0
43	68.2	69.2	69.5	70.0	70.2		70.4
44	68.0	69 4	69.7	70.2	70.4		70.2
45	67.6	69.2	70.3	70.6	70.4		70.7
46	67.0	67.2	68.0	68.0	68.1		68.0
47	69.0	70.3	70.4	70.4	70.4		70.6
48	68.4	69.1	69.6	69.7	69.6		69.6
49	67.5	68.2	68.2	68.6	68.7		69.0
50	68.3	69 2	70.0	70.0	70.5		71.0
51	68.0	69.0	70.0	70.0	70.3		70.2
52	67.5	67.6	68.2	68.2	68.5		
53	67.1	67.6	67.6	67.6	67.7		68.4
54	67.4	68.2	68.7	69.4	69.4		69.6
55	67.6	68.3	69.2	69.3	69.6		69.6
56	67.0	67.4	67.7	68.1			68.1
57	67.2	67.6	67.7	68.1	68.4		68.4
58	68.2	69.2	69.6	70.0	70.2		70.2
59	67.2	68.2	69.1	69.7	69.7		70.2
60	68.0	68.5	69.3	69.3	69.6		70.0
61	67.2	68.3	69.0	69.3	69.3		69.4
62	69.0	69.6	70.3	70 3	70.6		70.6
63	68.0			71.2	71.2	71.2	71.7
Av's..	68.0	68.7	69.2	69.5	69.8		70.0
$\pm d$ =	0.49	0.62	0.68	0.70	0.79		0.75

Fractions in columns are eighths; the averages and deviation represented in inches and tenths.

TABLE XV.

Individual and Continuous Measurements in Height, Standing. Middle-sized Group.

No.	Inches at the following years. 16	17	18	19	20	21	22
1	65.4	66.1	66.7	67.1	67.3		
2	66.0	67.0	67.3	67.6	67.5	67.5	
3	66.0	68.4	70.7	72.0	72.5		72.5
4		66.4	66.6	66.6	66.6	66.6	67.0
5	66.0	67.0	67.4	67.4	68.		68.1
6		67.0	67.2	67.2	67.5	67.6	67.6
7		65.1	65.4	65.7	65.7	65.3	
8	65.6	68.1	69.0	69.7	69.7		
9		66.2	67.1	68.2	68.6	68.7	68.6
10		66.2	67.1	68.2	68.6	68.7	68.6
11	65.3	66.2	66.5	66.6	67.0	67.0	
12	65.5	66.3	66.5	66.5	66.6		66.6
13	66.2	67.5	68.2	68.5	68.2		68.5
14		65.2	65.5	65.6	65.7	65.7	65.7
15	65.0	66.0	66.2	66.3	66.3		66.3
16	66.0	67.0	67.2	67.6	67.7		67 7
17	66.5	67.4	68.2	68.2	68.6		
18	65.1	65.7	66.4	66.4	66.4		66.4
19	65.0	65.6	66.6	66.6	66.6		66.6
20	66.0	66.4	66.6	66.6	66.6		66.6
21	66.4	67.0	67.5	68.0	68.0		68.0
22	66.4	67.0	67.3	67.5	67.4		67.4
23	66.2	68.0	68.6	69.0	69.0		69.0
24	66.1	67.3	68.1	69.0	69.0		69.0
25	66.1	66.5	67.0	67.0	67.0		67.2
26	65.1	65.4	65.4	65.4	65.5		67.5
27	66.3	67.3	67.5	67.4		67.5	
28	65.2	65.5	66.5	67.0	67.6		
29		65.0	66.4	67.2	67.3	67.5	67.5
30	66.1	67.5	68.6	68.7	68.7		69.0
31	65.2	65.5	66.5	67.0	67.6		
32	65.0	66 4	67.2	67.3	67.5		67.5
33	66.7	67.5	68.6	68.7	68.7		69.0
34		68.0	68.0	68.4	68.6	69.	69.4
35		66.6	68.0	68.4	68.4		70.0
36	65.2	66.0	67.0	67.0	67.3		67.3
37	66.1	67.7	69.2	70.0	70.2		
38	65.0	65.2	65.4	65.4	65.4		65.4
39	65.3	65.7	66.2	66.2	66.2		66.4
40	65.4	67.1	67.4	68.0	68.0		68.0
41	65.1	67.0	67.4	67.4			
42	66.7	67.2	67.2	67.2	67.5		
43	65.5	66.5	67.2	67.2		67.3	
44	65.4	67.0	67.6	68.0	68.4		68.4
45	65.4	67.0	67.4	68.1	68.5		68.5
46	65.2	66.2	67.2	67.2	67.5		
47	65.1	66.0	66.2	66.3	66.4		66.5
48	65.4	67.0	69.0	69.5	69.7		69.6
49	66.0	67.3	68.7	69.6	69.7		69.6
50	65.4	68.4	69.0	69.3	69.4	69.4	69.4
51	66.2	66.4	67.3	67.3		67.4	
52	66.2	66.4	67.4	67.4	67.4		
53	66.6	68.2	68.4	69.0	69.0		69.0
54	66.5	67.1	67.1	67.1	67.1		67.4
55	65.3	66.4	67.0	67.3	67.4	67.4	67.5
56	65.6	67.0	67.4	68.0	68.2	68.1	68.
57	65.2	65.6	66.0	66.5	66.7	67.0	67.0
58	66.4	67 4	67.7	68.1	68.4		68.5
59	65.3	66.4	67.2	68.0	68.2		68.5
60	66.1	67.3	67.7	67.4	67.2		67.3
61	66.6	67.2	68.5	68.5	68.7		69.
62	66.4	68.2	69.0	69.6	70.2		70.4
63	65.2	66.0	67.0	67.0	67.2		67.3
64	65.2	67.0	68.0	68.3	68.3		68.4
65	65.6	66.4	66.6	66.7		66.7	
66	65.4		67.0	67.0	67.2		67.2
67	65.6	65.6	65.6	66.2	66.0		66.2
68	65.0	67.0	67.5	68.0	68.0	68.0	68.2
69	66.4	67.2	68.3	68.7	69.2	69.4	69.4
70	65.5	66.2	67.1	67.0		67.2	
71	65.3	66.7	67.6	68.2	68.3	68.6	68.6
Av's..	65.7	66.7	67.4	67.7	67.9		68.0
$\pm d$ =	0.32	0.54	0.55	0.77	0.86		0.90

Table XVI.

Individual Continuous Measurements in Height, Standing. Short Group.

No.	Inches at the following years. 16	17	18	19	20	21	22
1	62.½	65.0	67.6	69.5	70.2		70.6
2	63.7	65.2	67.0	67.7	68.2		68.2
3	64.4	65.3	65.7	66.1	66.2		66.2
4	64.4	67.2	67.6	68.2	68.3		68.4
5	63.7	65.2	66.2	66.5	66.6		66.7
6	64.2	67.1	68.6	69.5	69.5		70.1
7	63.0	64.0	64.4	65.0	65.2		65.4
8	64.0	66.2	68.5	70.0	70.4		
9	64.0	65.0	65.4	66.0	66.2		67.4
10	64.6	65.7	66.6	67.3	67.4		67.5
11	63.2	65.0	66.7	67.5	68.0		68.1
12	64.0	65.6	67.5	68.2	68.5		68.4
13	64.1	65.6	67.5	68.2	68.5		68.4
14	63.7	64.3	64.3	64.7	64.7		64.6
15	64.4	66.4	67.6	68.1	68.4		68.4
16	64.4	65.1	65.3	65.6	66.1		66.4
17	64.3	65.6	66.6	67.1	67.1		67.2
18	61.0	62.7	64.4	65.2	66.1		66.3
19	61.3	63.5	65.0	65.5	65.6		65.7
20	63.6	64.5	65.0	65.0	65.3		65.7
21	63.2	65.6	65.7	65.7		66.0	
22	63.2	65.4	66.2	66.2		66.6	
23	64.3	65.6	66.6	67.1	67.3		
24	61.2	63.0	66.6	68.0	69.0	69.6	70.4
25	64.0	65.5	67.0	67.1		67.1	
26	63.2	64.2	64.7	64.5	64.6	64.7	65.2
27	63.4		67.7	68.1	68.1		68.6
28	60.4		64.2	65.2	66.7	67.0	67.0
29	62.6	63.5	64.4	65.0			
30	63.2	64.4	65.7	66.2	66.5		66.5
31	62.4	64.5	66.6	67.2	67.4		67.5
32	64.2		66.5	67.4	67.7		68.0
33	62.2		65.2	65.2	65.6		66.0
34	63.0	65.2	66.0	66.3	66.6		
35	62.1	64.6	65.6	66.1	66.4		67.0
36	64.0	64.5	65.3	65.4	66.0		66.0
37	62.7	65.2	66.4	66.6		67.0	
38	61.0	62.1	65.0	67.3	68.5		69.1
39	65.1	67.7	69.1	69.5		69.7	
40	63.0	64.2	65.2	65.3	65.6		66.
41	64.2	65.0	66.0	66.4	66.3		66.6
42	62.5	65.4	68.4	69.7	69.7		70.5
43	64.0	66.1	67.2	68.0			
44	62.0	63.3	64.5	65.2	65.2		65.3
45	63.5	65.2	66.6	67.4	67.6	67.6	67.6
46	64.5	64.5	64.7	64.7	65.1		65.2
47	61.0	63.0	65.0	65.6	66.0		66.0
48	62.2	65.2	67.0	67.4	67.7		68.0
49	64.1	65.2	66.1	67.2	67.3		67.5
50	63.0	64.4	68.0	69.0	69.3		69.4
51	63.1	66.2	67.0	68.0	68.3	68.2	68.6
52	62.4	65.3	66.6	68.5	69.2		69.6
Av's.	63.3	65.0	66.3	67.0	67.3		67.5
± d	0.13	0.61	0.90	1.06	1.07		1.07

Table XVII.

Averages and Probable Deviations calculated from certain limited measurements and from different years.

a. Small Group.

Inches.	16 years.	17 years.	18 years.	19 years.	20 years.	22 years.
63.5 — 64.7″ at	64.0 ± 0.2	65.6 ± 0.6	66.7 ± 0.6	67.2 ± 1.0	67.3 ± 1.1	67.4 ± 1.0
65.0 — 66.5″ at		65.6 ± 0.4	67. ± 0.6	67.4 ± 0.8	67.6 ± 0.7	67.6 ± 0.6
66.0 — 67.5″ at			67.0 ± 0.4	67.4 ± 0.4	67.6 ± 0.5	68.0 ± 0.5
67.0 — 68.5″ at				67.5 ± 0.35	68.0 ± 0.45	68.1 ± 0.45
68.0 — 69.5″ at					68.5 ± 0.3	68.7 ± 0.40
68.5 — 70.1						69.3 ± 0.42

b. Tall Group.

67.0 — 69.″ at	68.0 ± 0.49	68.7 ± 0.62	69.2 ± 0.68	69.5 ± 0.76	69.8 ± 0.79	70.0 ± 0.75
67.5 — 69.5 at		68.4 ± 0.56	69.2 ± 0.64	69.4 ± 0.74	69.6 ± 0.67	69.7 ± 0.62
68. — 70. at			69.3 ± 0.49	69.2 ± 0.56	69.4 ± 0.55	69.7 ± 0.54
68.5 — 70.5 at				69.4 ± 0.40	69.6 ± 0.42	69.7 ± 0.44
69.0 — 71.0 at					69.7 ± 0.40	69.8 ± 0.42
69.5 — 71.0 at						70.0 ± 0.26

Table XVIII.

Individual Increases in Height.

a. Short Group. *b.* Tall Group.

Inches.	*a.* Years. 16–17	17–18	18–19	19–20	20–22	*b.* Years. 16–17	17–18	18–19	19–20	20–22
.6		1.								
.5										
.4		1.								
.3										
.2										
.1	1.									
3	1.	1.								
.7	3.	1.								
.6	2.	1.								
.5	1.									
.4	2.									
.3	1.	1.	1.							
.2	4.									
.1	2.									
2	2.	1.								
.7	1.	3.	2.							
.6	3.	2.								
.5	2.	2.		1.		2.				
.4	2.	1.			1.	3.				
.3	5.	4.	2.			3.				
.2	2.	4.	1.		1.	4.	1.			
.1	3.	2.	1.			3.	2.			
1	3.	6.	3.	1.		7.	2.	1.	1.	
.7	3.	4.	3.	1.		4.	2.	1.		
.6	1.	3.	5.		1.	4.	8.	2.	1.	
.5	2.	1.	5.	2.	1.	11.	5.	2.	2.	2.
.4	1.	4.	8.	3.	6.	6.	10.	5.	1.	2.
.3		1.	8.	15.	4.		7.	10.	10.	4.
.2		2.	3.	8.	3.	4.	10.	11.	10.	9.
+ .1		1.	4.	7.	13.	4.	4.	6.	16.	8.
o	1.	1.	5.	6.	8.	2.	9.	21.	13.	10.
— .1				1.	3.				2.	8.
.2			1.						1.	2.
Total No.	48.	48.	52.	45.	42.	57.	60.	61.	57.	54.

TABLE XIX. The Height.

Age at nearest Birthday.	No. of observations.	Values in Inches at the following Percentile Grades.										
		5	10	20	30	40	50	60	70	80	90	95
15	131	59.507	60.310	61.563	62.553	63.457	64.290	64.855	65.764	66.653	67.717	69.290
16	395	61.750	62.549	63.714	64.580	65.250	65.805	66.455	67.200	68.020	69.000	70.406
17	722	63.130	64.217	65.165	65.853	66.434	67.000	67.626	68.317	69.100	70.320	71.320
18	841	64.193	65.000	65.886	66.483	67.044	67.633	68.251	68.920	69.665	70.320	71.530
19	750	64.680	65.391	66.250	66.844	67.424	67.651	68.600	69.243	69.786	71.000	71.880
20	645	64.962	65.543	66.413	67.094	67.675	68.252	68.810	69.477	70.253	71.280	72.180
21	493	64.970	65.620	66.433	67.054	67.667	68.215	68.852	69.483	70.180	71.120	72.000
22	328	64.945	65.831	66.580	67.200	67.762	68.352	68.960	69.927	70.632	71.543	72.258
23	232	65.287	65.800	66.580	67.300	68.010	68.522	69.030	69.625	70.307	71.240	72.000

TABLE XX. The Weight.

Age at nearest Birthday.	No. of observations.	Values in Pounds at the following Percentile Grades.										
		5	10	20	30	40	50	60	70	80	90	95
15	131	80.0	85.3	93.0	98.8	103.8	108.5	112.6	116.5	120.5	127.3	132.0
16	395	94.0	98.6	103.6	108.9	114.2	116.9	121.4	125.4	130.5	137.1	146.2
17	722	102.4	106.5	112.0	116.9	121.0	124.8	128.5	132.5	137.5	144.3	151.6
18	841	109.2	113.3	120.0	123.9	127.9	131.8	135.9	140.0	146.0	153.6	158.0
19	750	114.3	120.0	124.8	129.5	133.3	137.0	142.1	145.3	149.7	158.0	165.1
20	645	116.0	125.2	126.5	131.2	134.9	138.5	142.5	146.9	152.3	160.9	167.8
21	493	117.7	122.0	127.0	131.6	135.3	138.9	143.0	147.2	152.6	160.7	167.3
22	328	117.8	122.1	128.0	132.1	135.3	138.7	142.9	147.8	153.5	160.0	163.1
23	232	118.0	122.2	126.7	131.0	134.7	138.3	142.2	146.4	151.8	163.8	170.0

TABLE XXI. The Height, Sitting.

Age at nearest Birthday.	No. of observations.	Values in Inches in the following Percentile Grades.										
		5	10	20	30	40	50	60	70	80	90	95
15												
16	110	31.050	31.600	32.270	32.692	33.110	33.500	33.893	34.285	34.680	35.150	35.577
17	225	32.008	32.400	33.083	33.460	33.833	34.180	34.500	34.821	35.240	35.800	36.135
18	243	32.915	33.174	33.548	33.921	34.278	34.630	35.000	35.044	35.677	36.074	36.608
19	200	33.050	33.333	33.889	34.307	34.700	35.055	35.333	35.611	35.888	36.462	36.850
20	165	35.185	33.543	34.150	34.562	34.975	35.254	35.528	35.800	36.137	36.707	37.000
21	103	33.643	34.100	34.549	34.995	35.222	35.445	35.670	35.893	36.235	36.683	36.907
22	68	33.266	33.644	34.225	34.675	35.050	35.320	35.592	35.864	36.309	36.927	37.433
23	46	34.018	34.288	34.450	34.737	35.026	35.313	35.640	35.946	36.300	36.646	36.823

TABLE XXII. The Perineal Height.

Age at nearest Birthday.	No. of observations.	Values in Inches in the following Percentile Grades.										
		5	10	20	30	40	50	60	70	80	90	95
15	90	29.545	31.000	31.644	32.120	32.650	33.125	33.500	33.875	34.461	35.222	35.722
16	235	31.150	31.520	32.368	32.987	33.411	33.830	34.245	34.657	35.118	35.808	36.477
17	409	32.084	32.583	33.287	33.780	34.213	34.600	35.000	35.401	36.121	36.537	37.030
18	490	32.500	33.135	33.800	34.260	34.634	35.007	35.357	35.707	36.110	36.781	37.314
19	454	33.033	33.480	34.150	34.525	34.800	35.243	35.560	35.874	36.331	36.885	37.554
20	395	33.209	33.679	34.245	34.618	35.000	35.310	35.629	36.071	36.440	36.970	37.720
21	318	32.926	33.450	34.180	34.600	35.012	25.340	35.670	36.000	36.483	36.978	37.670
22	212	33.270	33.771	34.348	34.800	35.176	35.492	35.810	36.221	36.779	37.500	37.900
23	160	33.500	34.090	33.576	35.040	35.350	35.654	35.961	36.535	36.700	37.177	37.650

TABLE XXIII.

The Circumference of the Chest midway between Inspiration and Expiration.

Age at nearest Birthday.	No. of observations.	Values in Inches in the following Percentile Grades.										
		5	10	20	30	40	50	60	70	80	90	95
15	132	26.600	27.262	28.070	28.700	29.300	29.952	30.470	31.063	31.664	32.483	33.000
16	395	27.980	28.464	29.333	30.071	30.584	31.101	31.635	32.000	32.718	33.513	34.150
17	722	28.740	29.170	30.480	31.061	31.478	31.895	32.324	32.751	33.347	34.221	34.843
18	841	30.028	30.588	31.322	31.832	32.275	32.685	33.135	33.715	34.354	35.100	35.813
19	750	30.814	31.300	32.011	32.498	32.844	33.250	33.710	34.184	34.735	35.481	35.944
20	643	31.078	31.500	32.153	32.700	33.168	33.588	34.000	34.489	34.960	35.804	36.576
21	496	31.152	31.580	32.280	32.720	33.270	33.656	34.055	34.546	35.060	35.834	36.680
22	328	31.231	31.744	32.384	32.900	33.345	33.776	34.208	34.640	35.142	36.000	36.873
23	232	31.255	31.900	32.474	33.029	33.451	33.873	34.265	34.646	35.055	35.855	36.822

TABLE XXIV.

The Lung-capacity ascertained by means of the Spirometer.

Age at nearest Birthday.	No. of observations.	Values in Cubic Inches in the following Percentile Grades.										
		5	10	20	30	40	50	60	70	80	90	95
15	139	117.2	132.0	148.4	156.4	166.2	178.2	190.0	198.9	205.5	219.5	233.5
16	395	143.2	152.1	166.8	176.3	185.9	193.5	199.4	210.7	224.0	237.0	253.5
17	722	156.4	171.0	181.9	192.7	198.8	208.8	216.8	228.5	238.8	252.7	263.1
18	841	170.0	180.0	192.3	203.5	212.5	219.0	227.7	236.0	245.7	260.0	272.2
19	750	181.0	192.3	203.3	213.2	220.8	228.3	235.6	243.4	253.1	268.6	287.0
20	645	185.6	194.3	206.9	215.8	224.0	233.2	242.0	249.6	261.0	277.6	290.7
21	493	185.7	194.6	207.0	219.5	224.1	232.2	240.0	248.3	259.0	277.4	287.5
22	328	194.0	203.4	214.5	222.5	231.1	237.9	245.8	254.6	263.8	286.5	298.5
23	232	194.7	204.0	211.5	221.0	230.0	236.3	245.3	255.1	264.6	276.2	285.5

TABLE XXV.

The Span, in Inches, of the Arms.

Age at nearest Birthday.	No. of observations.	Values in the following Percentile Grades.										
		5	10	20	30	40	50	60	70	80	90	95
15	33	60.65	61.65	62.52	63.25	64.05	64.50	64.97	65.55	67.48	68.35	68.78
16	110	60.90	63.00	64.54	65.42	66.25	66.80	67.44	68.15	69.00	70.25	71.83
17	225	63.61	64.61	65.74	66.57	67.27	67.90	68.54	69.27	70.24	71.54	72.57
18	243	64.47	65.23	66.16	67.14	67.91	68.55	69.23	69.81	70.80	72.12	73.00
19	200	64.45	65.66	66.90	67.60	68.34	69.03	69.64	70.40	71.35	72.50	73.55
20	165	64.88	66.13	67.15	67.97	68.70	69.40	70.12	71.07	71.82	73.34	73.80
21	103	65.30	67.03	68.12	68.91	69.44	69.93	70.63	71.32	71.96	73.34	74.62
22	68	65.10	66.00	67.90	68.05	68.90	69.60	70.35	71.93	72.28	73.80	74.43
23	46	67.05	67.43	68.60	69.27	69.60	69.93	70.60	71.27	71.85	72.85	73.85

TABLE XXVI.

The Circumference, in Inches, of the Waist.

Age at nearest Birthday.	No. of observations.	Values in the following Percentile Grades.										
		5	10	20	30	40	50	60	70	80	90	95
15	134	21.67	22.67	23.50	24.09	24.62	25.12	25.53	25.93	26.53	27.60	28.61
16	395	23.23	23.75	24.47	25.06	25.41	25.77	26.18	26.71	27.31	27.97	28.80
17	722	23.84	24.38	25.13	25.57	26.00	26.45	26.90	27.42	27.96	28.78	29.48
18	841	24.21	24.86	25.69	26.28	26.75	27.22	27.70	28.21	28.59	29.68	30.43
19	750	24.33	25.20	26.03	26.60	27.15	27.60	28.05	28.53	29.02	29.82	30.65
20	645	24.68	25.32	26.19	26.83	27.32	27.98	28.26	28.53	29.58	30.66	31.40
21	493	24.58	25.23	26.07	26.66	27.21	27.69	28.21	28.85	29.62	30.54	31.19
22	328	25.09	25.53	26.24	26.76	27.28	27.81	28.35	28.91	29.46	30.25	31.00
23	232	24.87	25.53	26.40	27.03	27.46	27.89	28.48	29.13	29.84	30.85	31.70

TABLE XXVII.

Right Hand Squeeze in Pounds.

Age at nearest Birthday.	No. of observations.	Values at the following Percentile Grades.										
		5	10	20	30	40	50	60	70	80	90	95
15	46	38.0	40.6	46.3	53.0	58.6	60.0	64.0	68.0	70.3	79.0	80.0
16	120	51.0	55.5	59.0	62.1	65.2	68.0	70.7	73.5	76.8	81.2	90.0
17	225	57.1	60.7	66.1	70.0	72.5	75.2	78.0	81.0	84.2	89.4	94.0
18	243	62.8	65.7	68.0	70.4	74.5	77.2	80.1	83.1	86.6	91.7	96.8
19	200	65.6	68.8	72.6	73.9	78.8	82.0	85.2	88.1	91.6	97.6	102.5
20	165	66.2	69.7	74.7	77.8	80.3	83.8	86.8	89.8	95.2	99.0	103.0
21	103	67.1	71.0	75.6	79.6	82.7	85.8	89.5	92.7	96.7	102.1	107.0
22	68	66.0	68.4	72.5	77.0	81.6	85.0	87.1	89.2	94.4	98.9	105.0
23	46	68.9	72.0	78.6	83.8	86.7	89.0	92.1	95.5	97.6	99.7	107.1

TABLE XXVIII.

Left Hand Squeeze in Pounds.

Age at nearest Birthday.	No. of observations.	Values in the following Percentile Grades.										
		5	10	20	30	40	50	60	70	80	90	95
15	36	33.0	36.0	43.0	49.6	54.2	56.4	58.0	59.6	64.6	71.0	75.5
16	110	45.0	50.9	55.6	59.0	62.1	65.0	66.7	68.6	72.0	80.0	85.0
17	225	55.0	58.9	64.7	68.6	71.6	73.5	76.1	79.4	82.7	87.5	92.7
18	245	57.5	61.6	66.5	69.0	71.6	75.0	77.6	80.0	84.5	89.2	94.8
19	200	64.4	66.8	70.8	74.4	78.3	81.9	83.1	86.1	89.5	96.3	99.6
20	165	63.3	66.8	71.9	76.0	79.3	82.0	84.6	90.0	94.0	99.4	104.2
21	103	67.7	71.5	75.7	78.8	81.7	84.5	87.3	90.0	93.7	99.7	104.8
22	68	65.2	67.1	72.0	77.0	80.0	83.8	86.8	89.4	94.5	99.4	103.2
23	46	66.5	69.0	77.2	80.4	82.7	85.0	87.3	89.6	92.3	97.2	104.2

TABLE XXIX.
The Absolute Annual Increase in Weight in Pounds.

Age at nearest Birthday.	Values in the following Percentile Grades.											
	5	10	20	30	40	50	60	70	80	90	95	Average.
15–16	14.0	13.3	10.6	10.1	11.4	8.4	8.8	8.9	10.0	9.8	14.2	11.0
16–17	8.4	7.9	8.4	8.0	6.8	7.9	7.1	7.1	7.0	7.2	5.4	7.0
17–18	6.8	6.8	8.0	7.0	6.9	7.0	7.4	7.5	8.5	9.3	6.4	8.4
18–19	5.1	6.7	4.8	5.6	5.4	5.3	6.2	5.3	3.7	5.4	7.1	6.32
19–20	1.7	5.2	1.7	1.7	1.6	1.5	0.4	1.6	2.6	2.9	2.7	1.5
20–21	1.7	3.2	0.5	0.4	0.4	0.4	0.5	0.3	0.3	—0.2	—0.5	—1.2
21–22	—0.5	0.1	1.0	0.5	0.0	—0.2	—0.1	0.6	0.9	—0.7	—4.2	—1.3
22–23	2.8	0.1	1.3	—1.1	—0.6	—0.4	—0.7	—1.4	—1.7	3.8	6.9	2.7

TABLE XXX.
The Absolute Annual Increase in Height, Standing.

Age at nearest Birthday.	Values in Inches in the following Percentile Grades.											
	5	10	20	30	40	50	60	70	80	90	95	Average.
15–16	2.243	2.239	1.151	2.027	1.793	1.515	1.570	1.536	1.367	1.283	1.177	2.13
16–17	1.380	1.668	1.451	1.273	1.184	1.195	1.172	1.117	1.080	1.320	0.914	1.12
17–18	1.063	1.283	0.721	0.630	0.610	0.633	0.624	0.623	0.565	0.200	0.210	0.84
18–19	0.487	0.391	0.364	0.361	0.380	0.018	0.349	0.323	0.121	0.480	0.350	0.61
19–20	0.282	0.158	0.163	0.250	0.251	0.601	0.210	0.234	0.467	0.280	0.240	0.65
20–21	0.008	0.077	0.020	—0.040	—0.008	—0.037	0.042	0.006	—0.073	—0.160	—0.120	0.05
21–22	—0.025	0.211	0.147	0.146	0.095	0.137	0.108	0.444	0.452	0.423	0.258	—0.15
22–23	0.342	—0.031	0.000	0.100	0.248	0.170	0.070	—0.302	—0.325	—0.303	—0.258	0.17

TABLE XXXI.
The Absolute Annual Increase in Height, Sitting.

Age at nearest Birthday.	Values in Inches in the following Percentile Grades.											
	5	10	20	30	40	50	60	70	80	90	95	Average.
16–17	0.958	0.800	0.813	0.768	0.723	0.630	•.607	0.536	0.560	0.650	0.558	0.50
17–18	0.907	0.774	0.465	0.461	0.445	0.450	0.500	0.223	0.437	0.274	0.467	0.75
18–19	0.135	0.159	0.341	0.386	0.422	0.425	0.333	0.567	0.211	0.388	0.248	0.75
19–20	0.135	0.210	0.261	0.255	0.275	0.199	0.195	0.189	0.249	0.245	0.150	0.73
20–21	0.458	0.557	0.399	0.433	0.247	0.191	0.142	0.093	0.098	—0.024	—0.093	—0.23
21–22	—3.77	—0.456	—0.324	—0.320	—0 172	—0.125	—0.078	—0.029	0.074	0.244	0.526	0.00
22–23	0.732	0.644	0.225	0.062	—0.024	0.013	0.048	0.082	—0.009	—0.281	0.390	0.00

TABLE XXXII.
The Absolute Annual Increase in Perineal Height.

Age at nearest Birthday.	Values in Inches in the following Percentile Grades.											
	5	10	20	30	40	50	60	70	80	90	95	Average.
15–16	1.625	0.220	0.724	0.867	0.761	0.705	0.745	0.782	0.657	0.586	0.755	1.20
16–17	0.934	1.363	0.919	0.793	0.802	0.770	0.745	0.744	1.003	0.729	0.553	0.80
17–18	0.416	0.532	0.513	0.480	0.421	0.407	0.357	0.306	0.091	0.244	0.284	0.60
18–19	0.533	0.345	0.350	0.265	0.166	0.236	0.203	0.167	0.221	0.104	0.240	1.30
19–20	0.166	0.193	0.095	0.093	0.200	0.067	0.069	0.197	0.109	0.085	0.166	—0.50
20–21	—0.273	—0.229	—0.065	—0.018	0.019	0.030	0.041	—0.071	0.043	0.002	—0.050	—1.00
21–22	0.344	0.321	0.168	0.200	0.164	0.152	0.140	0.221	0.296	0.528	0.230	1.00
22–23	0.290	0.319	0.228	0.240	0.174	0.169	0.151	0.314	—0.079	—0.323	— .085	0.00

TABLE XXXIII.
The Absolute Annual Increase in Circumference of Chest.

Age at nearest Birthday.	Values in Inches in the following Percentile Grades.											
	5	10	20	30	40	50	60	70	80	90	95	Average.
15–16	1.383	1.202	1.263	1.371	1.284	1.149	1.165	0.937	1.043	1.030	1.150	1.17
16–17	0.757	0.706	1.147	0.990	0.894	0.794	0.689	0.751	0.635	0.708	0.693	0.83
17–18	1.288	1.418	0.942	0.771	0.797	0.790	0.811	0.964	1.007	0.879	0.970	0.94
18–19	0.786	0.712	0.689	0.596	0.569	0.565	0.575	0.469	0.381	0.381	0.131	1.54
19–20	0.264	0.200	0.142	0.278	0.321	0.338	0.290	0.305	0.235	0.323	0.532	—0.70
20–21	0.074	0.080	0.127	0.080	0.105	0.068	0.055	0.057	0.100	0.030	0.104	0.00
21–22	0.079	0.164	0.104	0.180	0.075	0.120	0.153	0.106	0.082	0.166	0.193	0.05
22–23	0.084	0.156	0.090	0.129	0.066	0.097	0.057	0.006	—0.087	—0.145	—0.051	0.45

TABLE XXXIV.
The Absolute Annual Increase in Lung-capacity. (Spirometer.)

Age at nearest Birthday.	Values in Cubic Inches in the following Percentile Grades.											
	5	10	20	30	40	50	60	70	80	90	95	Average.
15–16	26.0	20.1	18.4	19.9	19.7	15.3	9.4	11.8	18.5	17.5	20.0	18.0
16–17	13.2	18.9	15.1	16.4	12.9	15.3	17.4	17.8	14.8	15.7	9.6	16.0
17–18	14.4	9.0	10.4	10.8	13.7	10.2	10.9	8.5	6.9	7.3	9.1	9.0
18–19	11.0	12.3	11.0	9.7	8.3	9.3	7.9	7.4	7.4	8.6	14.8	14.0
19–20	4.6	2.0	3.6	2.6	3.2	5.9	6.4	6.2	7.9	9.0	3.7	—1.0
20–21	0.1	0.3	0.1	3.7	0.1	0.0	—2.0	—1.3	—2.0	— 1.02	— 3.2	2.0
21–22	8.3	8.8	7.5	2.0	7.0	5.7	5.8	6.3	4.8	19.1	11.0	5.0
22–23	0.7	0.6	3.0	—1.5	—1.1	—1.6	—0.5	0.5	0.8	—10.3	—13.0	—4.0

TABLE XXXV.
The Absolute Annual Increase in Circumference of Waist.

Age at nearest Birthday.	Values in Inches in the following Percentile Grades.											
	5	10	20	30	40	50	60	70	80	90	95	Average.
15-16	1.56	1.08	0.97	0.97	0.79	0.65	0.65	0.78	0.78	0.37	0.19	0.91
16-17	0.61	0.63	0.66	0.51	0.59	0.68	0.72	0.71	0.65	0.81	0.68	1.36
17-18	0.37	0.48	0.56	0.71	0.75	0.77	0.80	0.79	0.63	0.90	0.95	0.54
18-19	0.12	0.34	0.34	0.32	0.40	0.38	0.35	0.32	0.43	0.14	0.22	0.30
19-20	0.35	0.12	0.16	0.23	0.17	0.38	0.21	0.30	0.56	0.84	0.75	0.09
20-21	—0.10	—0.09	—0.12	—0.17	—0.11	—0.29	—0.05	0.08	0.04	—0.12	—0.21	0.06
21-22	0.51	0.30	0.17	0.10	0.07	0.12	0.14	0.06	—0.16	—0.29	—0.19	0.12
22-23	—0.22	0.00	0.16	0.27	0.18	0.08	0.13	0.28	0.38	0.50	0.70	0.40

TABLE XXXVI.
The Absolute Annual Increase in the Span of Arms.

Age at nearest Birthday.	Values in Inches in the following Percentile Grades.											
	5	10	20	30	40	50	60	70	80	90	95	Average.
15-16	0.25	1.35	2.02	2.17	2.20	2.30	2.47	2.60	1.52	1.90	3.05	3.43
16-17	2.71	1.61	1.20	1.15	1.02	1.10	1.10	1.12	1.24	1.29	0.74	0.77
17-18	0.86	0.62	0.42	0.67	0.64	0.65	0.69	0.54	0.56	0.58	0.46	1.25
18-19	—0.02	0.43	0.74	0.46	0.43	0.48	0.41	0.53	0.55	0.32	0.55	0.80
19-20	0.43	0.47	0.25	0.37	0.30	0.37	0.48	0.67	0.47	0.84	0.25	—0.02
20-21	0.42	0.50	0.97	0.94	0.74	0.53	0.51	0.25	0.14	0.00	0.80	0.57
21-22	—1.20	—1.03	—0.92	—0.86	—0.54	—0.33	—0.28	—0.09	0.32	0.44	—0.19	—0.47
22-23	2.95	1.43	1.40	1.22	0.70	0.33	0.25	—0.06	—0.43	—0.95	—0.58	—0.80

TABLE XXXVII.
The Absolute Annual Increase in Right Hand Squeeze.

Age at nearest Birthday.	Values in Pounds in the following Percentile Grades.											
	5	10	20	30	40	50	60	70	80	90	95	Average.
15-16	13.0	14.9	12.7	9.1	6.6	8.0	6.7	5.5	6.5	3.1	10.0	10.50
16-17	6.1	5.2	7.1	7.9	7.3	7.2	7.3	7.5	7.4	7.3	4.0	5.97
17-18	5.7	5.0	1.9	0.4	2.0	2.3	2.1	2.1	2.4	2.3	2.8	3.53
18-19	2.8	3.1	4.6	5.5	4.3	4.5	5.1	5.0	5.0	5.9	5.7	4 00
19-20	0.6	0.9	2.1	1.9	1.5	1.8	1.6	1.7	3.6	1.4	1.2	2.00
20-21	0.9	1.3	0.9	1.8	2.4	2.0	2.7	2.9	1.5	3.1	3.3	1.00
21-22	—1.1	2.0	—3.1	—2.6	—1.1	—0.8	—2.4	—3.5	—2.3	—3.2	—2.0	—1.50
22-23	2.9	3.6	6.1	6.8	5.2	4.0	5.0	6.3	3.2	0.8	2.1	0.10

TABLE XXXVIII.
The Absolute Annual Increase in Left Hand Squeeze.

Age at nearest Birthday.	Values in Pounds in the following Percentile Grades.											
	5	10	20	30	40	50	60	70	80	90	95	Average.
15-16	12.0	14.9	12.6	9.4	7.9	8.6	8.7	9.0	7.4	9.0	9.5	10.0
16-17	10.0	8.0	9.1	9.6	9.5	8.5	9.4	10.8	10.7	7.5	7.7	6.6
17-18	2.1	2.7	1.8	0.4	0.0	1.5	1.5	0.6	1.8	1.7	2.1	3.4
18-19	7.3	5.2	4.3	5.4	6.7	6.5	5.5	6.1	5.0	7.1	4.8	3.0
19-20	—1.1	0.0	1.1	1.6	1.0	0.5	1.5	3.9	4.5	3.1	4.6	2.0
20-21	4.3	4.7	3.8	2.8	2.4	2.5	2.7	0.0	—0.3	0.3	0.6	2.4
21-22	—2.5	—4.4	—3.7	—1.8	—1.7	—0.7	—0.5	—0.6	0.8	—0.3	—1.6	—1.6
22-23	1.3	1.9	5.2	3.4	2.7	1.2	0.5	0.2	—2.2	—2.2	1.0	—1.1

TABLE XXXIX.
The Relative Annual Increase in Weight. (Pounds.)

Age at nearest Birthday.	Values in Per Cent. in the following Percentile Grades.											
	5	10	20	30	40	50	60	70	80	90	95	Average.
15-16	13.1	12.4	10.0	9.4	10.6	8.0	9.2	8.3	9.3	9.2	13.2	10.3
16-17	7.1	6.7	7.1	6.8	5.8	6.7	6.0	6.0	6.0	6.0	4.6	6.0
17-18	5.4	5.4	6.4	5.6	5.5	5.6	6.0	6.0	6.8	7.4	5.1	6.7
18-19	3.8		3.7	4.2	4.0	4.0	4.7	4.0	2.3	4.0	5.3	5.0
19-20	1.2	3.7	1.2	1.2	1.1	1.1	0.3	1.1	1.8	2.1	2.0	1.1
20-21	1.2	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	—0.1	—0.3	—0.8
21-22	—0.4	0.1	0.7	0.4	0.0	—0.4	—0.1	0.4	0.6	—0.5	—3.0	—1.0
22-23	2.0	0.1	—0.9	—0.8	—0.4	—0.3	—0.5	—1.0	—1.2	2.7	4.9	2.0

TABLE XL.
The Relative Annual Increase in Height, Standing. (Inches.)

Age at nearest Birthday.	Values in Per Cent. at the following Percentile Grades.											
	5	10	20	30	40	50	60	70	80	90	95	Average.
15-16	3.51	3.51	1.80	3.17	2.72	2.37	2.41	2.41	2.14	2.01	1.84	3.34
16-17	2.00	2.53	2.20	1.93	1.79	1.81	1.79	1.71	1.64	2.02	1.08	1.70
17-18	1.58	1.91	1.07	0.93	0.91	0.93	0 93	0.90	0 83	0.30	0.31	0.36
18-19	0.72	0.58	0.54	0.53	0.56	0.03	0.52	0.47	0.17	0.72	0.52	0.91
19-20	0.41	0.22	0.24	0.37	0.37	0.88	0.30	0.34	0.68	0.41	0 35	0.93
20-21	0.001	0.01	0.003	—0.058	—0.012	—0.058	0.061	0.008	—0.107	—0.232	—0.175	0.073
21-22	—0.036	0.307	0.214	0.214	0.138	0.200	0.157	0.647	0.647	0.616	0.367	—0.215
22-23	0.500	—0.045	0.000	0.146	0.362	0.248	0.108	—0.441	—0.474	—0.442	—0.377	0.248

TABLE XLI.

The Relative Annual Increase in Height, Sitting. (Inches.)

Age at nearest Birthday.	Values in Per Cent. at the following Percentile Grades.											
	5	10	20	30	40	50	60	70	80	90	95	Average.
16-17	2.87	2.40	2.44	2.30	2.17	2.04	1.82	1.61	1.68	1.95	1.95	1.50
17-18	2.60	2.21	1.30	1.30	1.27	1.21	1.43	0.64	1.25	0.78	1.30	2.14
18-19	0.38	0.44	0.95	1.08	1.18	1.18	0.93	1.58	0.59	1.08	0.69	2.10
19-20	0.37	0.60	0.71	0.70	0.75	0.52	0.52	0.50	0.68	0.68	0.41	2.00
20-21	1.28	1.55	1.11	1.21	0.69	0.53	0.39	0.27	0.29	—0.08	—0.27	—0.62
21-22	—1.05	—1.26	—0.90	—0.90	—0.48	—0.35	—0.21	—0.08	0.20	0.68	1.46	0.00
22-23	2.10	1.80	0.62	0.17	—0.07	0.03	0.13	0.23	—0.02	—0.77	1.08	0.00

TABLE XLII.

The Relative Annual Increase in Perineal Height. (Inches.)

Age at nearest Birthday.	Values in Per Cent. at the following Percentile Grades.											
	5	10	20	30	40	50	60	70	80	90	95	Average.
15-16	5.00	0.70	2.26	2.71	2.30	2.20	2.33	2.44	2.05	1.83	2.36	3.80
16-17	2.81	4.10	2.16	2.38	2.41	2.32	2.24	2.24	3.02	2.20	1.70	2.41
17-18	1.22	1.62	1.51	1.41	1.24	1.20	1.05	0.90	0.30	0.72	0.84	1.77
18-19	1.54	1.00	1.01	0.74	0.48	0.69	0.58	0.47	0.64	0.30	0.70	3.76
19-20	0.46	0.55	0.26	0.26	0.58	0.19	0.19	0.55	0.30	0.24	0.46	—2.30
20-21	—0.40	—0.33	—0.09	—0.027	0.020	0.04	0.103	—0.10	0.06	0.003	—0.07	—1.459
21-22	0.96	0.89	0.47	0.57	0.47	0.41	0.39	0.61	0.82	1.46	0.64	2.77
22-23	0.01	0.88	0.64	0.66	0.50	0.45	0.42	0.90	—0.22	—0.90	—0.89	0.00

TABLE XLIII.

The Relative Annual Increase in Circumference of Chest. (Inches.)

Age at nearest Birthday.	Values in Per Cent. at the following Percentile Grades.											
	5	10	20	30	40	50	60	70	80	90	95	Average.
15-16	4.54	3.93	4.14	4.50	4.21	3.77	3.82	3.62	3.40	3.37	3.77	3.83
16-17	2.39	2.83	3.62	3.12	2.82	2.50	2.17	2.38	2.01	2.23	2.29	2.62
17-18	3.96	4.36	2.90	2.37	2.45	2.44	2.30	2.97	3.09	2.70	2.97	2.90
18-19	2.34	2.13	2.06	1.78	1.70	1.70	1.72	1.41	1.14	1.14	0.40	4.60
19-20	0.75	0.57	0.40	0.80	0.91	0.96	0.85	0.90	0.67	0.92	1.32	—1.00
20-21	0.21	0.83	0.37	0.06	0.30	0.20	0.16	0.16	0.30	0.09	0.30	0.00
21-22	0.23	0.47	0.30	0.52	0.21	0.36	0.44	0.30	0.23	0.47	0.56	0.62
22-23	0.07	0.45	0.26	0.36	0.19	0.28	0.16	0.01	—0.25	—0.42	—0.15	1.40

TABLE XLIV.

The Relative Annual Increase in Lung Capacity. (Cb. Inches.)

Age at nearest Birthday.	Values in Per Cent. at the following Percentile Grades.											
	5	10	20	30	40	50	60	70	80	90	95	Average.
15-16	14.2	10.1	11.0	11.0	11.0	8.3	5.1	6.4	10.1	9.5	11.0	10.0
16-17	6.5	7.5	9.4	8.1	6.4	7.6	8.6	8.9	7.3	7.8	4.7	8.0
17-18	6.6	4.8	4.1	5.0	6.3	4.7	5.0	4.0	3.2	3.3	4.2	4.1
18-19	4.8	4.8	5.4	4.3	3.7	4.1	3.5	3.3	3.3	3.8	6.6	6.2
19-20	1.9	1.5	0.8	1.1	1.3	2.5	2.7	2.2	3.3	3.8	1.6	—2.4
20-21	0.04	0.04	0.12	1.60	0.04	0.00	—0.83	—0.54	—0.84	—0.43	—1.34	0.84
21-22	3.40	3.11	3.65	0.83	2.90	2.37	2.37	2.61	2.00	7.39	4.60	2.08
22-23	0.28	—1.22	0.24	—0.60	—0.45	—0.60	—0.20	0.20	0.32	—4.20	—5.29	—1.62
		20 P. G.	10 P. G.									

TABLE XLV.

The Relative Annual Increase in Circumference of Waist. (Inches.)

Age at nearest Birthday.	Values in Per Cent. at the following Percentile Grades.											
	5	10	20	30	40	50	60	70	80	90	95	Average.
15-16	6.21	4.30	3.86	3.86	3.15	2.35	2.35	3.15	3.50	1.50	0.75	3.63
16-17	2.35	2.42	2.54	2.00	2.27	2.64	2.77	2.77	2.50	3.11	2.64	3.23
17-18	1.34	1.75	2.04	2.59	2.73	2.81	2.92	2.90	2.30	3.28	2.81	2.00
18-19	0.43	1.22	1.22	1.11	1.43	1.36	1.25	1.11	1.54	0.50	0.80	1.08
19-20	1.23	0.42	0.56	0.80	0.59	1.33	0.73	1.50	2.00	3.00	2.62	0.07
20-21	—0.35	—0.31	—0.42	—0.60	—0.39	—1.01	—0.17	0.07	0.14	—0.42	—0.73	0.21
21-22	1.77	1.24	0.60	0.34	0.24	0.42	0.49	0.21	—0.55	—1.01	—0.66	0.41
22-23	—0.76	0.00	0.55	0.93	0.62	0.28	0.45	0.76	1.32	1.73	2.42	1.40

TABLE XLVI.
The Relative Annual Increase in Span of Arms. (Inches.)

Age at nearest Birthday.	Values in Per Cent. at the following Percentile Grades.											
	5	10	20	30	40	50	60	70	80	90	95	Average.
15-16	0.39	2.11	3.15	3.86	3.58	3.60	3.86	4.10	2.38	2.97	4.76	5.37
16-17	4.04	2.40	1.78	1.71	1.51	1.63	1.63	1.64	1.79	1.80	1.00	1.14
17-18	1.26	0.91	0.61	1.00	0.95	0.95	1.01	0.71	0.72	0.72	0.63	1.83
18-19	—0.02	0.62	1.06	0.66	0.62	0.67	0.61	0.85	0.79	0.46	0.79	1.15
19-20	0.61	0.67	0.35	0.52	0.51	0.52	0.68	0.95	0.67	1.19	0.35	—0.03
20-21	0.60	1.28	1.38	1.34	1.05	0.75	0.74	0.35	0.20	0.00	1.17	0.81
21-22	—1.70	—1.45	—1.30	—1.21	—0.76	—0.46	—0.40	—0.12	0.45	0.62	—0.27	—0.66
22-23	4.20	2.03	2.00	1.73	1.00	0.47	0.35	—0.08	—0.61	—1.35	—0.82	1.14

TABLE XLVII.
The Relative Annual Increase in Right Hand Squeeze. (Pounds.)

Age at nearest Birthday.	Values in Per Cent. at the following Percentile Grades.											
	5	10	20	30	40	50	60	70	80	90	95	Average.
15-16	21.3	24.4	20.8	15.0	10.8	13.1	11.0	9.0	10.6	5.1	16.4	17.2
16-17	8.5	7.2	10.0	11.0	10.2	10.1	10.2	10.5	10.3	19.2	5.6	8.3
17-18	7.3	6.4	2.4	0.5	2.6	3.00	2.7	2.7	3.1	3.0	3.6	4.5
18-19	3.5	3.8	5.7	6.8	5.3	5.5	6.3	6.2	6.2	7.3	7.0	5.0
19-20	0.7	1.0	2.4	2.2	1.7	2.1	1.8	2.0	4.2	1.0	1.4	2.3
20-21	1.0	1.5	1.0	2.1	2.7	2.3	3.1	3.3	1.7	3.5	3.8	1.1
21-22	—1.2	—3.00	—3.5	—3.0	—1.2	—0.9	—2.7	—4.0	—2.6	—3.6	—2.2	—1.7
22-23	3.3	4.2	7.3	7.8	5.9	4.6	5.8	7.4	3.7	0.9	2.4	0.1

TABLE XLVIII.
The Relative Annual Increase in Left Hand Squeeze. (Pounds.)

Age at nearest Birthday.	Values in Per Cent. at the following Percentile Grades.											
	5	10	20	30	40	50	60	70	80	90	95	Average.
15-16	20.0	25.0	21.0	16.0	13.1	14.3	14.5	15.0	12.3	15.0	15.1	16.6
16-17	14.3	11.4	13.0	13.7	13.5	12.1	13.4	15.4	15.3	10.7	11.0	9.1
17-18	2.7	3.5	2.3	0.5	0.0	2.0	2.0	0.8	2.3	2.2	2.7	4.4
18-19	9.1	6.5	5.4	6.7	8.4	8.1	7.0	7.6	6.2	8.8	6.0	3.8
19-20	—1.3	0.0	1.3	1.9	1.2	0.6	1.8	4.7	5.4	3.8	5.5	2.4
20-21	5.0	5.5	4.4	3.3	2.8	2.9	3.2	0.0	—0.3	0.3	0.7	2.8
21-22	—2.8	—5.0	—4.3	—2.1	—2.0	—0.8	—0.6	—0.7	0.9	—0.3	—1.8	—1.8
22-23	1.5	2.2	6.0	4.0	3.1	1.4	0.6	—0.2	—2.5	—2.5	1.2	—1.3

TABLE XLIX. The Height, Standing.

Age at nearest Birthday.	No. of Observations.	Unit of Measurement.	Average.	Probable Error of Average.	Probable Deviation.	Relation of Probable Deviation to Average.	Absolute Ann'l Increase of Average.	Relative Ann'l Increase of Average.	25 Percentile Grade.	Median or 50 Percentile Grade.	75 Percentile Grade.	Median Minus Average.
				E	d	d/A						
15	131		63.80	±0.136	±1.96	2.65%			62.058	64.290	66.208	+ 0.490
16	393		65.93	±0.080	±1.56	2.36	2.13	3.34%	64.147	65.850	67.610	— 0.125
17	722		67.05	±0.059	±1.59	2.37	1.12	1.70	65.509	67.000	68.708	— 0.050
18	841		67.29	±0.057	±1.68	2.50	0.24	0.36	66.184	67.633	69.292	+ 0.343
19	750		67.90	±0.054	±1.30	2.21	0.61	0.91	66.547	67.651	69.514	+ 0.249
20	645		68.35	±0.060	±1.50	2.18	0.65	0.95	66.753	68.252	69.865	— 0.298
21	493		68.60	±0.071	±1.58	2.30	0.05	0.073	66.743	68.215	69.831	— 0.385
22	328		68.45	±0.086	±1.56	2.27	—0.15	—0.215	66.894	68.352	70.280	— 0.098
23	232		68.62	±0.099	±1.51	2.20	0.17	0.248	66.940	68.522	69.980	— 0.098

TABLE L. The Weight.

Age at nearest Birthday.	No. of Observations.	Unit of Measurement.	Average.	Probable Error of Average.	Probable Deviation.	Relation of Probable Deviation to Average.	Relation of Average to Height, Standing.	Absolute Ann'l Increase of Average.	Relative Ann'l Increase of Average.	25 Percentile Grade.	Median or 50 Percentile Grade.	75 Percentile Grade.	Median Minus Average.
				E	d	d/A							
15	131		107.0	±0.922	±10.60	10.0%	16.7%			95.9	108.5	118.5	+ 1.5
16	395		118.0	±0.531	±10.56	8.9	18.2	11.0	10.3%	106.2	116.9	127.8	— 1.1
17	722		125.0	±0.370	±9.94	7.9	18.6	7.0	6.0	114.4	124.8	135.0	— 0.2
18	841		133.4	±0.400	±11.28	8.4	20.0	8.4	6.7	121.9	131.8	143.0	— 1.5
19	750		139.7	±0.360	±9.86	7.0	20.5	6.3	5.0	127.1	137.0	147.5	— 2.7
20	695		141.2	±0.371	±9.43	6.7	20.6	1.5	1.1	128.8	138.5	149.6	— 2.7
21	493		140.0	±0.456	±10.14	7.2	20.4	—1.2	—0.8	129.3	138.9	149.9	— 1.1
22	328		141.3	±0.500	±9.07	6.4	20.6	—1.3	—1.0	130.1	138.7	150.6	— 2.6
23	232		144.0	±0.768	±11.81	8.2	21.0	2.7	2.0	128.9	138.3	149.1	— 5.7

TABLE LI. The Height, Sitting.

Age at nearest Birthday.	No. of Observations.	Unit of Measurement.	Average.	Probable Error of Average.	Probable Deviation.	Relation of Probable Deviation to Average.	Relation of Average to Height, Standing.	Absolute Ann'l Increase of Average.	Relative Ann'l Increase of Average.	25 Percentile Grade.	Median or 50 Percentile Grade.	75 Percentile Grade.	Median Minus Average.
				E	*d*	*d/A*							
15	131		33.3	±0.088	±1.01	3.03%	42.7%						
16	395		34.5	±0.048	±0.96	2.80	52.3			32.481	33.500	34.829	−1.000
17	722		35.0	±0.032	±0.86	2.46	52.5	0.50	1.50%	33.271	34.180	35.030	−0.820
18	841		35.7	±0.027	±0.81	2.27	53.0	0.75	2.14	33.735	34.630	35.360	−1.120
19	750		36.5	±0.035	±0.98	2.70	53.7	0.75	2.10	34.098	35.055	35.749	−1.445
20	695		35.7	±0.027	±0.70	1.96	52.1	0.73	2.00	34.356	35.254	35.967	−0.516
21	493		36.0	±0.084	±0.54	1.50	52.4	−0.23	−0.62	34.772	35.445	36.064	−0.555
22	328		36.0	±0.040	±0.74	2.05	52.5	0.00	0.00	34.450	35.320	36.087	−0.680
23	232		36.0	±0.036	±0.57	1.58	52.4	0.00	0.00	34.593	35.333	36.123	−0.667

TABLE LII. The Perineal Height.

Age at nearest Birthday.	No. of Observations.	Unit of Measurement.	Average.	Probable Error of Average.	Probable Deviation.	Relation of Probable Deviation to Average.	Relation of Average to Height, Standing.	Absolute Ann'l Increase of Average.	Relative Ann'l Increase of Average.	25 Percentile Grade.	Median or 50 Percentile Grade.	75 Percentile Grade.	Median Minus Average.
				E	*d*	*d/A*							
15	131		32.0	±0.131	±1.51	4.72%	50.1%			31.582	33.125	34.168	
16	395		33.2	±0.064	±1.29	3.89	53.5	1.20	3.80%	32.678	33.830	34.887	
17	722		34.0	±0.045	±1.25	3.67	50.7	0.80	2.41	33.531	34.600	35.761	
18	841		34.6	±0.040	±1.22	3.52	51.4	0.60	1.77	34.030	35.007	35.909	
19	750		35.9	±0.031	±0.86	2.40	52.8	1.30	3.76	34.338	15.243	36.102	
20	695		35.0	±0.038	±0.98	2.80	51.1	−0.90	2.50	34.431	35.310	36.256	
21	493		34.0	±0.076	±1.69	4.97	50.0	−1.00	−1.46	34.392	35.340	36.241	
22	328		35.0	±0.062	±1.14	3.26	51.1	1.00	2.77	34.574	35.492	36.500	
23	232		35.0	±0.073	±1.12	3.20	51.0	0.00	0.00	34.803	35.654	36.617	

TABLE LIII. The Circumference of Chest.

Age at nearest Birthday.	No. of Observations.	Unit of Measurement.	Average.	Probable Error of Average.	Probable Deviation.	Relation of Probable Deviation to Average.	Relation of Average to Height, Standing.	Absolute Ann'l Increase of Average.	Relative Ann'l Increase of Average.	25 Percentile Grade.	Median or 50 Percentile Grade.	75 Percentile Grade.	Median Minus Average.
				E	*d*	*d/A*	*A/H*						
15	132		30.50	±0.123	±1.42	4.65%	47.8			28.385	29.952	31.363	−0.548
16	395		31.67	±0.066	±1.33	4.20	48.0	1.17	3.83%	29.707	31.101	32.336	−0.569
17	722		32.50	±0.044	±1.23	3.78	48.5	0.83	2.62	30.770	31.895	33.034	−0.605
18	841		33.46	±0.043	±1.26	3.50	49.7	0.94	2.90	31.577	32.685	34.034	−0.775
19	750		35.00	±0.038	±1.04	3.00	51.5	1.54	4.60	32.219	33.250	34.459	−1.750
20	695		34.30	±0.048	±1.22	3.55	50.3	−0.70	−2.00	32.426	33.588	34.724	−0.712
21	493		34.30	±0.052	±1.16	3.40	50.0	0.00	0.00	32.500	33.656	34.803	−0.644
22	328		34.35	±0.065	±1.18	3.43	51.8	0.05	0.02	32.642	33.776	34.891	−0.574
23	232		34.80	±0.079	±1.20	3.45	50.7	0.45	1.40	32.751	33.873	34.850	−0.927

TABLE LIV. The Lung Capacity.

Age at nearest Birthday.	No. of Observations.	Unit of Measurement.	Average.	Probable Error of Average.	Probable Deviation.	Relation of Probable Deviation to Average.	Relation of Average to Height, Standing.	Absolute Ann'l Increase of Average.	Relative Ann'l Increase of Average.	25 Percentile Grade.	Median or 50 Percentile Grade.	75 Percentile Grade.	Median Minus Average.
				E	*d*	*d/A*	*A/H*						
15	132		183	±2.303	±26.10	14.2%	40.9			152.4	178.2	202.2	−4.8
16	395		395	±1.091	±21.69	10.8	32.9	18.0	10.0%	176.5	193.5	217.8	−7.5
17	722		722	±0.820	±22.00	10.1	33.0	16.0	8.0	187.3	208.8	233.6	−8.2
18	841		841	±0.782	±22.87	10.1	34.0	9.0	4.1	197.9	219.0	240.8	−7.0
19	750		750	±0.642	±19.60	8.8	28.8	14.0	6.2	208.2	228.3	248.2	−11.7
20	675		675	±0.834	±21.19	8.8	30.8	−1.0	−0.4	211.3	233.2	255.3	−5.8
21	493		493	±0.940	±20.84	8.6	30.2	2.0	0.84	213.2	232.2	253.6	−8.8
22	328		328	±1.190	±20.83	8.5	30.4	5.0	2.08	218.5	237.9	259.2	−8.1
23	232		232	±1.950	±16.05	7.9	27.8	−4.0	−1.62	216.2	236.3	259.8	−5.7

TABLE LV. The Circumference of the Waist.

Age at nearest Birthday.	No. of Observations.	Unit of Measurement.	Average.	Probable Error of Average. E	Probable Deviation. d	Relation of Probable Deviation to Average. d/A	Relation of Average to Height, Standing. A/H	Absolute Ann'l Increase of Average.	Relative Ann'l Increase of Average.	25 Percentile Grade.	Median or 50 Percentile Grade.	75 Percentile Grade.	Median Minus Average.
15	132		25.09	±0.095	±1.09	4.34%	3.93						
16	395		26.00	±0.052	±1.03	4.00	3.94	0.91	3.63%	23.79	25.12	26.23	+ 0.03
17	722		27.36	±0.042	±1.13	4.13	4.08	1.36	5.22	24.76	25.77	27.01	— 0.23
18	841		27.90	±0.044	±1.30	4.66	4.14	0.54	2.08	25.35	26.45	27.69	— 0.91
19	750		28.60	±0.044	±1.21	4.23	4.21	0.30	1.08	25.98	27.22	28.40	— 0.68
20	695		28.62	±0.052	±1.33	4.64	4.17	0.02	0.07	26.31	27.60	28 76	— 1.00
21	493		28.68	±0.062	±1.28	4.48	4.21	0.06	0.21	26.51	27.98	29.20	— 0.64
22	328		28.80	±0.070	±1.38	4.81	4.18	0.12	0.41	26.38	27.67	29.23	— 0.99
23	232		29.20	±0.093	±1.42	4.86	4.25	0.40	1.40	26.50	27.81	29.17	— 0.99
										26.71	27.89	29.47	— 1.31

TABLE LVI. The Span of Arms.

Age at nearest Birthday.	No. of Observations.	Unit of Measurement.	Average.	Probable Error of Average. E	Probable Deviation. d	Relation of Probable Deviation to Average. d/A	Relation of Average to Height, Standing. A/H	Absolute Ann'l Increase of Average.	Relative Ann'l Increase of Average.	25 Percentile Grade.	Median or 50 Percentile Grade.	75 Percentile Grade.	Median Minus Average.
15	36		63.90	±0.130	±1.18	1.84%	100.0						
16	110		67.33	±0.091	±1.81	2.69	102.1	3.43	5.37	62.89	64.50	66.51	+ 0.60
17	225		68.00	±0.064	±1.74	2.56	101.1	0.77	1.14	64.98	66.80	68.57	— 0.53
18	245		68.25	±0.060	±1.75	2.53	102.8	1.25	1.83	66.15	67.90	69.75	— 0.10
19	200		70.18	±0.062	±1.72	2.45	103.3	0.80	1.15	66.65	68.55	70.30	— 0.70
20	165		70.10	±0.072	±1.85	2.64	102.2	—0.08	—0.03	67.25	69.03	70.87	— 1.09
21	103		70.67	±0.076	±1.68	2.37	103.1	0.57	0.81	67.56	69.40	71.45	— 0.70
22	68		70.20	±0.108	±1.98	2.81	102.5	—0.47	—0.66	68.52	69.93	71.64	— 0.74
23	46		71.00	±0 093	±1.42	2.00	103.4	0.80	1.14	67.62	69.60	71.75	— 0.60
										68.93	69.93	71.56	— 1.07

TABLE LVII. The Right Hand Squeeze.

Age at nearest Birthday.	No. of Observations.	Unit of Measurement.	Average.	Probable Error of Average. E	Probable Deviation. d	Relation of Probable Deviation to Average. d/A	Relation of Average to Height, Standing. A/H	Absolute Ann'l Increase of Average.	Relative Ann'l Increase of Average.	25 Percentile Grade.	Median or 50 Percentile Grade.	75 Percentile Grade.	Median Minus Average.
15	36		62.0	±0.820	±9.12	13.0	95.4%						
16	110		71.5	±0.367	±7.30	10.2	108.0	10.50	17.20%	49.5	60.0	69.1	—1.0
17	223		77.5	±0.273	±7.33	9.0	115.6	5.97	8.30	60.5	68.0	75.0	—3.5
18	245		81.0	±0.245	±7.11	8.1	120.3	3.53	4.50	68.0	75.2	82.6	—3.2
19	200		85.0	±0.274	±7.52	8.8	125.2	4.08	5.00	69.2	77.5	84.8	—3.5
20	165		77.0	±0.316	±8.03	9.2	127.0	2.00	2.00	74.2	82.0	89.8	—3.0
21	103		88.0	±0.365	±8.11	9.2	128.3	1.00	2.30	76.2	83.8	92.5	—3.2
22	68		86.5	±0.449	±8.14	9.4	126.5	—1.50	—1.70	77.6	85.8	94.7	—3.2
23	46		86.6	±0.421	±6.42	7.6	126.2	0.10	0.10	74.7	85.0	91.8	—1.5
										81.2	89.0	96.5	+0.4

TABLE LVIII. The Left Hand Squeeze.

Age at nearest Birthday.	No. of Observations.	Unit of Measurement.	Average.	Probable Error of Average. E	Probable Deviation. d	Relation of Probable Deviation to Average. d/A	Relation of Average to Height, Standing. A/H	Absolute Ann'l Increase of Average.	Relative Ann'l Increase of Average.	25 Percentile Grade.	Median or 50 Percentile Grade.	75 Percentile Grade.	Median Minus Average.
15	36		60.0	±0.790	±9.06	15.1	94.0%						
16	110		70.0	±0.368	±7.31	10.4	106.2	10.0	16.6%	46.3	56.4	69.1	—3.6
17	225		76.6	±0.274	±7.43	9.7	114.3	6.6	9.1	56.2	65.0	78.3	—5.0
18	245		80.0	±0.250	±7.22	9.0	119.0	3.4	4.4	66.6	73.5	82.0	—3.1
19	200		83.0	±0.273	±7.43	9.0	122.2	3.0	3.8	67.7	75.0	82.2	—5.0
20	166		85.0	±0.322	±8.19	9.6	124.0	2.0	2.4	72.6	81.5	87.8	—3.5
21	103		97.4	±0.327	±7.26	8.1	127.4	2.4	2.8	73.9	82.0	92.0	—5.0
22	68		85.8	±0.463	±8.40	9.3	125.3	—1.6	—1.8	77.2	84.5	91.8	—3.0
23	46		84.7	±0.466	±7.10	8.3	123.3	—1.1	—1.3	74.5	83.8	91.9	—4.9
										78.8	85.0	90.9	—4.0
													+0.3

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THE TRAINING SERVICE.

A FEW NOTES.

By Lieut. George R. Clark, U. S. Navy.*

The recent wise step made by Congress in giving to the Navy two thousand more enlisted men should call attention to the importance of having an adequate training service for our "man behind the gun." In 1879 England employed one-eleventh of her commissioned officers on training duty, while to-day we devote one officer in thirty-seven to that service. Again, England finds work for one-eighth of her warrant officers in that important field, while we give to it one in nineteen.

It has not required all of a two years' experience in the training service to show me that everything possible has been done with the limited means at hand; but when it is remembered that the only cruising vessels now available for this work are the Essex and the Alliance, it will be seen that the means at hand for keeping up our supply of 1500 boys are clearly inadequate.

Naturally, the first thought is to turn to Congress and ask for two or three vessels designed with a view to the special needs of the service; but that would take much time and not a little pleading, and meanwhile the men and boys are being enlisted.

If the Bering Sea trouble should straighten itself out enough to allow the Pacific Squadron to be reduced, I think it would relieve the situation to send around the Adams and the Marion (or Iroquois), fit them out with modern batteries like those of the Essex and the Alliance and add them to the squadron. They would then be in a condition to render effective aid on regular cruising duty when needed.

With this addition the number of boys carried by each of the smaller ships could be reduced from 108 to 90, thus giving more

*U. S. Training Ship Essex.

room and adding to the comfort of all on board. As thus formed the squadron could readily train, in two cruises a year, all the boys from the Newport station, the average yearly enlistments there being about 720. If we could carry out this idea, and add the Lancaster as a gunnery ship, making short trips of a week's length from Newport, and serving as a "reservoir," so to speak, for the newly enlisted landsmen and boys returned from other vessels, we would have, at least, a step forward.

I would suggest that the four vessels be directed to cruise together in charge of the senior commanding officer, making a summer cruise to the Azores, Gibraltar, Madeira and Yorktown from July to November, and a winter cruise to the West Indies from January to May; November and May of each year being devoted wholly to target practice either at Yorktown or Gardiner's Bay, and December and June to be spent in port refitting.

The plan of visiting foreign ports excites the interest of the boys, increases their desire for further sea-going, and thus satisfies them with a service which they find has its compensations and rewards. In this, too, the commanding officer is furnished with a system of rewards and punishments in the granting or withholding of shore privileges, which can be used with good effect.

The practice in signals and the emulation and interest in drills and exercises generally that would result from squadron sailing could not fail to be of great benefit.

The key to success in training apprentices is to excite their interest. This once done, the rest is plain sailing.

A month of each cruise would not be too much to devote to exercises on shore and to target practice, for I think all will agree that, after all, the main thing in the training of men is to teach them "to fire at something and hit it." And, happily, this is something in which boys take a great interest and show gratifying progress after a very little instruction. A glance at the target report of the Navy for the quarter ending June 30th, 1894, will show that the Essex, with a crew of boys, stood No. 3 in a total of nine vessels. Among the first ten in a total of 258 firing, *seven* were Essex boys, each with a final merit of 100 or over. Among the first 64 were 40 boys from the same ship. This satisfactory showing was made at their first trial. If each draft of boys could be allowed at least two practices even better results could be obtained.

The subject of target practice may be considered the most important, with boats and signals following in the order named.

In regard to the methods of instruction and routine at sea and in port, a close observation of the methods employed convinces me that the principle of continuous instruction in one branch for a considerable length of time is the best. Those who "go down to the sea in training ships" know that it is difficult to make a boy think, and the next best thing is to employ what may be called the method of "reiteration"; that is, to keep at one subject until the boy gets it by absorption, so to speak. His thinking gear will gradually get in order as he grows older.

The truth of this is shown by our exercise at reefing topsails. This work is done six times a week without fail during the whole cruise, and even the dullest boys show a skill at the work that is encouraging.

Of this Commodore Bunce has said: "Training apprentices is best done by the repetition of facts until they are impressed on the memory, and in the repetition of acts until facility in doing them is acquired."

Speaking of this subject in a recent report to my commanding officer I said: "This principle of continuous instruction in one branch should be extended to the general routine at sea, where the time covering the whole cruise should be divided into five equal parts: the first devoted to sails, spars, compass and log; the second to marline-spike work and sail-making; the third to signals; the fourth to a review, and the fifth month to target practice. A half-hour each day to be given to gunnery."

This would carry out the principle as nearly as possible with a due regard to the number of subjects to be covered and the length of the cruise.

Again quoting from report: "The time spent on training ships should be regarded more as a preparatory and less as a finishing period. If, in the short time allowed, a boy be taught the importance of prompt obedience to orders, the general principles of discipline, the elementary branches of his calling and the confidence and skill gained in work aloft and general ship duties, all will be done that should be expected. The rest should be left to the actual work and the association with older men that come with service on board the cruisers."

In this connection I suggest that so far as possible the boys be

formed in one division on the cruisers, preferably at the secondary battery, in charge of a divisional officer and aid, who shall be responsible for their instruction and have general charge of them while on board. The instruction should be systematic and progressive.

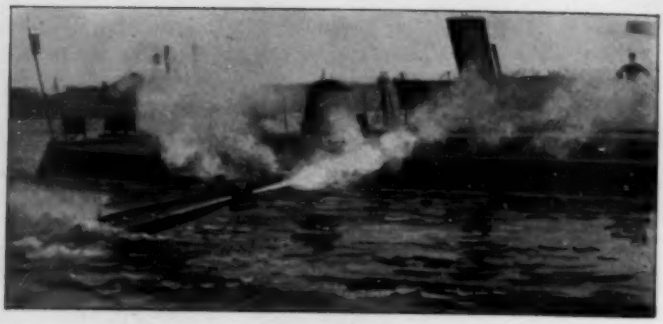
An officer of one of the new cruisers recently remarked that the work of examining apprentices took a long time. When asked how many he had examined that day, he said "forty." On board the training ship it takes a week to examine that number.

I know that I have laid down no elaborate plan, but if these few disconnected remarks attract any attention to this important subject they will have served their purpose.

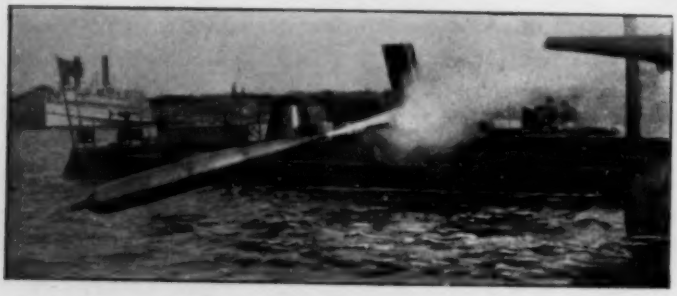
In conclusion I cannot do better than to quote from Commodore Chadwick's report on the training system of France:

"The necessity of so training these men is clearly felt by the officers of the French navy in general; without this widespread feeling much of the instruction given in training schools, however perfect, must go for naught."

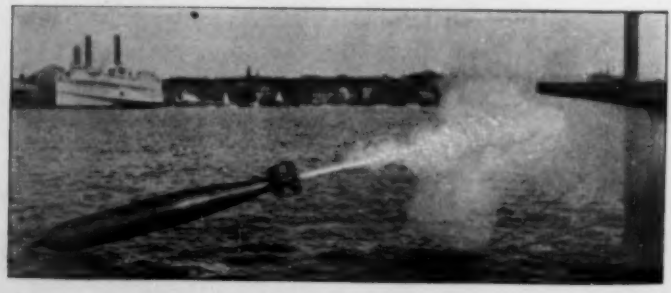
UofM



PHOTOGRAPH NO. 1.



PHOTOGRAPH NO. 2.—TORPEDO NO. 6—RUN NO.12.



PHOTOGRAPH NO. 3.—TORPEDO NO. 6—RUN NO. 10.

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THE PROBLEM OF TORPEDO DISCHARGE.

Compiled from the report of Lieutenant Frank F. Fletcher, U. S. Navy, commanding U. S. Torpedo-boat Cushing.

By Lieut. Albert Gleaves, U. S. Navy.

"Successful torpedo practice depends to the greatest extent upon successful discharge."—Lieut. Fletcher.

Previous to Lieutenant Fletcher's investigations of the subject comparatively little was known of torpedo ballistics. For the purpose of solving the problem of torpedo discharge Lieutenant Fletcher inaugurated and carried to a successful issue a series of experiments at Newport, R. I., which extended over several months, with the gratifying results of defining the relation between discharge and the final submerged angle of the torpedo, and establishing certain rules of fire that will not fail to rob the torpedo of its reputation for eccentricity, reduce to a minimum the errors of practice, and enable the gun-captain to handle the weapon with an intelligent idea of what may be expected of it under given conditions of discharge.

The official report gives a minute account of the experiments, which are remarkable alike for originality, simplicity and ingenuity. The details are admirably worked out, and where results do not blend, the discrepancies may be justly ascribed to the inaccuracies, not to say crudeness, of the recording instruments; they affect in no way the principles involved. The report itself, as a technical document, is exceedingly unique, using the word in its favorable sense.

By permission of the Bureau of Ordnance the substance of Lieutenant Fletcher's report to the President of the Torpedo Board is herewith given to the service. As nearly as may be consistent with the plan of this article the phraseology of the report is retained; for obvious reasons the methods employed and the instruments used in the experiments are touched upon lightly.

Generally speaking torpedoes are discharged from tubes that may be mounted either in broadside or in bow or stern, and in our service are installed above water. Broadside tubes are fitted with spoons, as shown in the partial midship section of the Cushing, Plate I; bow and stern tubes are fitted with the ball pivot. In this case the pivot tube takes the place of the spoon.

When discharged the torpedo is guided through the tube by means of a steel T stud located on top of the torpedo at its center of gravity. This stud travels in a slot extending the full length of the tube and spoon. The windage of the torpedo varies in different tubes and may be as small as a few hundredths or as great as 0.2 inch. Generally speaking, however, when the torpedo is in place it should take the grease all around the tube.

Before taking up Lieutenant Fletcher's report a close study should be made of the diagrams on Plate I, which graphically represent all the data relative to a normal run of a Whitehead torpedo; the essence of his report is contained in this chart, and it may be said that familiarity with these diagrams constitutes a fundamental requirement to a clear understanding of all that follows here.

With the mechanism in adjustment the most potent factor in the successful run of a torpedo is the initial dive, and this depends directly upon the angle at which the torpedo enters the water. This angle must be such that the resultant effect places the torpedo beneath the surface of the water pointing in the line of fire and at such an inclination that it will neither rise to the surface nor make a greater dive than 20 feet without coming under the influence of its own controlling mechanism. As the conditions that affect the angle of entry are not the same in all ships, it is of the highest importance to know how to vary each one so as to produce at all times a uniform *submerged* angle of entry, because it is this final angle that determines the depth to which the torpedo will make its initial dive.

There are five elements that influence the angle of entry; these may work together to produce a satisfactory result or they may be either partially or altogether opposed to each other. They are:

I. Impulse pressure (p).
II. Initial velocity (v).
III. Height of tube (h).
IV. Inclination of axis of tube (a).
V. Length of spoon (l).

RECORD OF A WHIT

TORPEDO

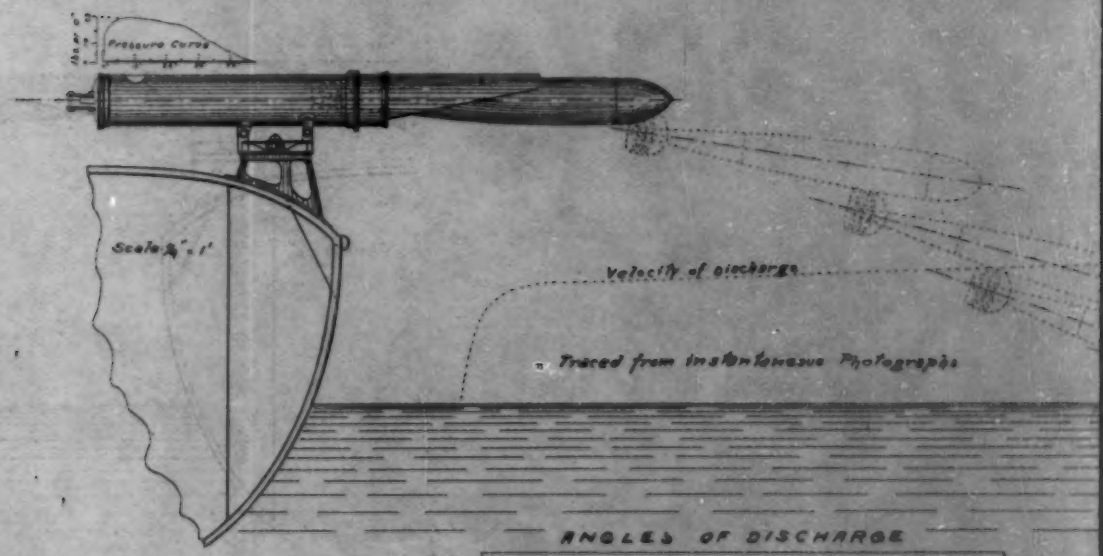
U.S.S. CUSHI

PRESSURE CURVE

CHARGE	ONE LAYER OF SPHERES HEXAGONAL IN THE BOTTOM AND FILLED TO THE TOP OF SPINDLE WITH SQUARE GRAIN
PRESSURE	DEVELOPED BEFORE THE TORPEDO MOVED — 4 LBS
MAXIMUM	PRESSURE — 23 LBS
DISTANCE	TORPEDO MOVED BEFORE MAXIMUM PRESSURE DEVELOPED — 7"

VELOCITY

TIME	TO EXECUTE
TIME	TO IGNITE AND TO MOVE
VELOCITY IN BORE OF	
VELOCITY IN AIR	
— " — " —	2"
— " — " —	3"



ANGLES OF DISCHARGE

DEPRESSION OF TUBE	0°
HEIGHT	8'-8"
DISTANCE FROM END OF SPOON AT WHICH THE HEAD STRUCK THE WATER	28 FT.
ANGLE OF ENTERING THE WATER	18°
ANGULAR MOTION PER SECOND OF FALL	26°

SHEET NO 1

RECORD OF A WHITEHEAD TORPEDO

TORPEDO NO. 6 RUN NO. 15

U. S. S. CUSHING OCT. 29

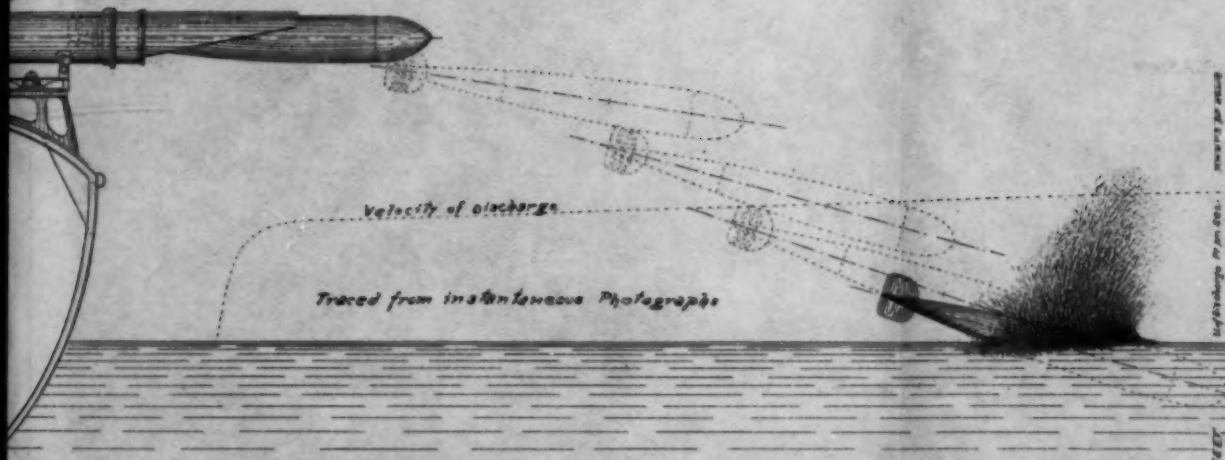
R. R. Fletcher Lieutn. U.S.

SURE CURVE

...ER OF SPHERS HEXAGONAL
... BOTTOM AND FILLED TO THE
... SPINDLE WITH SQUARE GRAIN
...ADED BEFORE THE TORPEDO
...O — — — — — 4 LBS
...SURE — — — — 23 LBS
...DO MOVED BEFORE MAXIMUM
...SURE DEVELOPED — 7"

VELOCITY OF DISCHARGE

TIME TO EXECUTE ORDER FIRE	.3 sec.
TIME TO IGNITE THE CHARGE AND TO MOVE THE TORPEDO	.18 sec.
VELOCITY IN BORE OF GUN	28 Ft per Sec.
VELOCITY IN AIR 1st 8 Ft	31.3
" " " 2nd 8 Ft	34.0
" " " 3d 8 Ft	34.0



ANGLES OF DISCHARGE

DEPRESSION OF TUBE	0°
HEIGHT	9'-8"
DISTANCE FROM END OF SPOON AT WHICH THE HEAD STRUCK THE WATER	23 Ft.
ANGLE OF ENTERING THE WATER	18°
ANGULAR MOTION PER SECOND OF FALL	26°

DIST. IN YDS.
TIMES SEC.

PEDO DISCHARGE

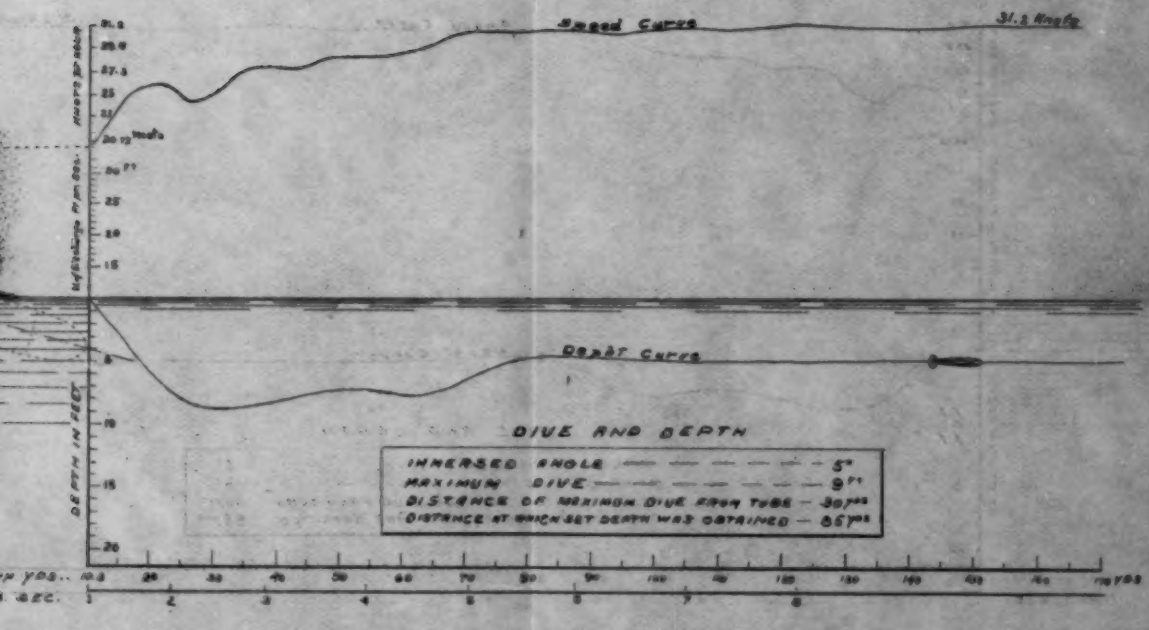
NO. 15.

CT. 29 1894.

hm. U.S.N. Comdg.

SPEED CURVE

SPEED WHEN FULLY IMMERSED	19 Knots
ACCELERATION PER SECOND	5 Feet
FULL SPEED	31.2 Knots
TIME TO OBTAIN FULL SPEED FROM ENTERING THE WATER	4 Seconds
DISTANCE AT WHICH FULL SPEED WAS ATTAINED	70 YARDS



DIVE AND DEPTH

IMMERSED ANGLE	5°
MAXIMUM DIVE	9 Ft
DISTANCE OF MAXIMUM DIVE FROM TUBE	30 Yds
DISTANCE AT WHICH SET DEPTH WAS OBTAINED	65 Yds

RECORD OF A

ANGLES OF DISCHARGE

To Lieutenant Fletcher belongs the distinction of discovering the relation of these quantities to each other and to the angle of entry.

Before considering in detail the effect of the elements just enumerated it will be well to take in account what occurs in the tube when the powder charge is exploded. (See Plate I.)

As soon as a pressure of about 5 lbs. is developed in rear of the torpedo it begins to move and quickly attains a velocity of about 32 feet per second. When the guide stud leaves the T slot at the end of the spoon the C. G. begins to fall while the tail is still supported some distance inside the tube. During the time the torpedo is traveling the distance necessary to free the tail its motion is that of a pendulum, and the C. G. swings through a small arc with a constantly accelerating rate, due to gravity. The angular motion in the vertical plane thus imparted to the torpedo will continue at a uniform rate at the instant the tail begins to fall until the torpedo strikes the water. The value of this angular impulse depends directly upon the velocity of discharge, and a variation in the velocity gives a corresponding variation in the angle of entry of the torpedo for any given height of tube. Again, the angle of entry depends upon the time through which the angular impulse has acted, and is materially different whether discharged from a tube 4 feet or 10 feet above the water.

When the torpedo is free from the tube, its velocity of discharge remaining practically constant, a vertical velocity is also imparted to it by the accelerating force of gravity.

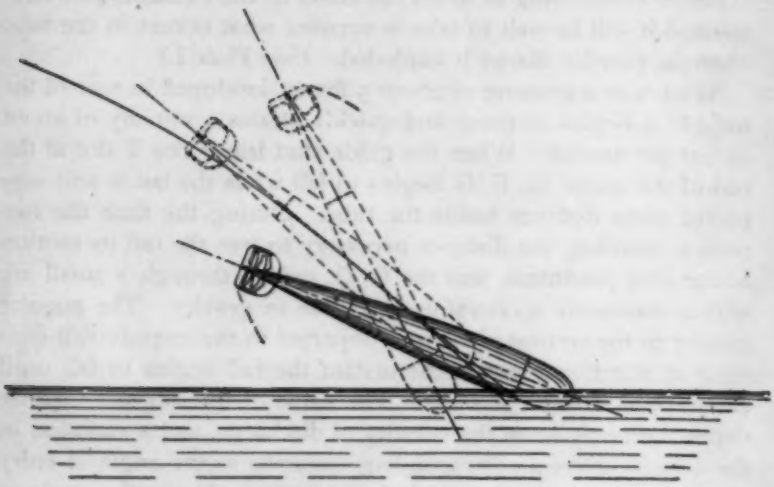
Thus, upon striking the water, the torpedo not only has an angular motion around its center of gravity, but a lateral velocity due to the impulse pressure and a vertical velocity due to gravity.

The resultant direction of motion is therefore at an angle to the surface of the water depending upon the two velocities, and the direction of its axis is also at an angle to the surface depending upon velocity of discharge, height and depression of tube.

The axis of the torpedo being inclined downwards, the head of the torpedo first strikes the water and is considerably retarded in the denser medium, while the after portion is free to fall through the air. The angular motion is thus not only checked, but a reverse angular motion takes place, tending to bring the torpedo back to horizontal. (See Fig.)

A combined electric speed and pressure indicator was especially

designed by Lieutenant Fletcher for his experiments. The instrument worked satisfactorily and recorded with sufficient accuracy the data relating to pressure, velocity and speed.



The initial dive was obtained by a net, and in connection with this the depth register was used; thus the accuracy of the register was not only verified, but the dive before and after passing the net was obtained.

The angular movement of the torpedo was ascertained from a series of instantaneous photographs.

From the known position of the torpedo when entering the water, its known depth at the net, and also by means of the reading of the depth register, the final submerged angle was readily obtained.

A consideration of each element that affects the angle of entry and its influence upon that angle is now in order.

I.—Impulse Pressure and Velocity.

The charge of powder used for discharging the torpedo is about 4 ounces, one ounce of which is sphero-hexagonal pellets, laid in the bottom of the cartridge case, and the other 3 ounces are square grains such as are used in the 6-pdr. R. F. G.

The average maximum pressure in the tube was found to be about 21 lbs. per sq. in. and the velocity of discharge about 30

ft. secs. The torpedo moves when the pressure reaches about 5 lbs. per sq. in., and the maximum pressure is attained when the torpedo has moved about 4 inches. The maximum pressure is maintained for a distance of 10 inches and then gradually falls to 0. When the pressure disappears the tail of the torpedo is still 4½ feet inside the tube and the guide stud or C. G. 1½ feet from the end of the spoon. Before the pressure ceases the windage increases to 2 inches in the last 2¾ feet of travel.

The recording instrument was set to measure the velocity at every 8 feet. It recorded the instant the torpedo started and also the time required for it to move 1, 2, 3, 4 or 5 feet. It is clear, therefore, that the personal error of the gun-captain, or, what is the same thing, the time required to execute the order "Fire," was ascertained without difficulty. The data relative to velocity of discharge is tabulated on the chart; the increase of velocity after the first 5 feet is due to the accelerating force of gravity after the torpedo is free from the tube. The velocity of discharge was found to be 6.8 ft. secs. less than the average maximum velocity and about 4 feet less than the muzzle velocity. The average muzzle velocity was about 33 ft. secs.

Great stress has been laid by torpedoists upon the necessity of having a uniform velocity of discharge; but Lieutenant Fletcher is of the opinion that this has been unduly exaggerated. He found that pressures from 15 to 18 lbs. per sq. in. produce an average velocity of 29.8 ft. secs., while with pressures from 20 to 23 lbs. per sq. in. the averages were as follows:

Pressure.	Velocity.
20 lbs.	31.1 ft. secs.
21 "	32.6 "
22 "	32.6 "
23 "	35.2 "

A variation of 2 lbs. does not appear to influence the velocity of discharge except as shown by a number of averages, and Lieutenant Fletcher concludes that the importance of uniform impulse pressures, after making due allowance for inaccuracies of recording instrument, has been greatly exaggerated. He says:

"I have noticed that when several variable elements combine to induce a final result observers are apt to differ widely as to the cause of any variation in the results obtained. Thus when a torpedo broaches from its initial dive one observer attributes the fact

to too small a height of tube above the water, another is quite sure it is due to escape of gas around the packing ring, while a third is equally positive that it is caused by grit beneath the reducing valve."

II.—Height of Tube above Water and Angle of Depression.

The pendulum-like action of the torpedo between the tube and water has been referred to, and from what has been said it is perfectly clear that the height of the tube has a very important bearing upon the angle at which the torpedo enters the water. The higher the tube, other things being equal, the longer will the torpedo be in reaching the water, and consequently the greater will be the angle that the axis of the torpedo will make with the surface of the water where it strikes. So also it will be admitted that a depression of the tube will increase this angle and by an amount equivalent to the angle of depression.

The experiments showed that with a height of tube between 5 and 6 feet the initial dive is about 9 feet, but from a tube 3 feet higher the dive is nearly doubled (17¼ ft.).

The influence of depression is more positive and regular, and it was deduced that a difference in the angle of depression of 6° has about the same effect upon the initial dive as an increase of 4 feet in height of tube above water. As a rule, then, *the initial dive is increased by the height of the tube above water and by the angle of depression.*

If this is not so the reason for the exception must be looked for in the variableness of the muzzle or horizontal velocity and the vertical velocity acquired by the torpedo when it leaves the tube, for it is these two velocities that determine the direction in which the torpedo is moving when it strikes the water.

The angular motion of the torpedo as it falls from the tube to the water has already been explained; it is evident that the rate at which it revolves around its C. G. is that which it had obtained at the instant the tail left the tube. Upon this angular motion depends the *entering angle* for the various conditions of discharge, and it is apparent that the value of this motion must depend upon the horizontal and vertical velocities mentioned above. Its value and the time of fall were accurately determined from instantaneous photographs. Its value was also determined

theoretically. When the guide stud or C. G. of the torpedo leaves the end of the spoon and is free to fall, the tail is still 2.27 feet within the tube. The muzzle velocity recorded by the chronograph of 32 ft. secs. will give $\frac{2.27}{32}$ as the time of falling of C. G., during which the torpedo may be regarded as a compound pendulum. At the end of this time the C. G. has fallen .0766 ft. and has swung through an arc of fifty minutes; its velocity is therefore $\frac{32 \times 2.27}{32} = 2.27$ ft. secs. The angular velocity will be represented by an angle whose sine is 2.27 divided by the distance of the center of oscillation from the point of support on the tail, or 25° 30′ per second of fall. This is not mathematically correct, but it demonstrates the truth of the principles involved and agrees very closely with results obtained from the photographs.

From a knowledge of the law which determines the value of this angular motion of discharge we are thus enabled to ascertain how much the entering angle or initial dive is influenced by a variation in the muzzle velocity.

			Entering Angle.		
M. V.	Ang. Vel. per sec.	Ht. of Tube - - Time of Fall - -	5 ft. .56 sec.	7 ft. .66 sec.	10 ft. .79 sec.
26	31°.5		17° 38′	20° 48′	24° 48′
30	25°.83		14° 30′	17° 05′	20° 35′
34	21°.07		11° 48′	13° 54′	16° 40′

A variation of 8 feet in the velocity of discharge causes a variation of from 6° to 8° in the angle of entry of the torpedo according to the height of tube from which it is fired. The table also shows that the combined influence of 8 ft. variation in velocity and 5 ft. variation in height of tube can be made to cause a change in the angle of entry amounting to 13°. If the above influences are combined with that also obtained by 8° extreme depression of the tube the total influence exerted upon the angle of entry can be made to exceed 20°.

The service impulse charge gives a M. V. that varies from 30.5 to 34.5 ft. secs. A variation of 4 ft. secs. cause an increase in the angle of entry of 2¾° from a tube 5 ft. high and 3½° from a tube 10 ft. high. These variations would probably not increase the initial dive more than four or five feet. From this it may be said in general that *a variation of 1 ft. in the velocity of discharge will cause a variation of about ¾° in the angle of the torpedo entering the water.*

The photographs that were taken not only afforded a means of tracing the actual position of the torpedo in air, but they also served as a means by which the velocities recorded by chronograph could be checked. The angular velocity was readily calculated by measuring the angle between the axis of the torpedo and the horizontal and the time of falling. With the angular velocity thus obtained and the known length of spoon the velocity of discharge was obtained. The velocity could be obtained also from the vertical and horizontal distance of the torpedo from the tube. The velocities obtained from the photographs agreed quite closely with those measured by the chronograph.

III.—Length of Spoon.

Upon the length of the spoon more than upon any other condition of discharge depends the angular motion of the torpedo around the C. G. and, consequently, its angle of entry. It can be shown that the sine of this angular velocity varies directly as the distance of the tail within the tube; thus *the shorter the spoon the greater is the angular velocity and entering angle.*

The length of spoon in use in the service is 5 feet. *For every inch this spoon is shortened it should make a difference of about* 1° *per second of fall.*

IV.—Comparative Value of the Conditions v, h, a and l.

What has been said refers only to the effect exerted by the above conditions individually upon the angle of entry. The effect of a change in one of the conditions can be offset by a proper variation of any other condition. That is, if a tube mounted 7 ft. above the water be lowered by the amount of 3 ft. 2 in. the angle of entry will be decreased by 4° 25′. This effect can be counteracted in any one of three ways: 1st, decrease length of spoon by 6 in.; 2d, increase the depression of the tube 4° 25′; 3d, decrease the velocity of discharge by 5.5 ft. secs.

V.—The Angle of Entry and Direction of Motion.

It has already been pointed out that when the torpedo first strikes the water the head is considerably retarded, while the after portion is free to fall through the air; that the influence of the various conditions which have been discussed determines the position of the axis of the torpedo at the instant of impact with the

water; that the consequent retardation tends to reverse the angular motion, and that the resultant of these forces modifies the angle of entry and determines the *final submerged angle* upon which the initial dive directly depends.

This is illustrated in Plate II. The torpedo is plotted in three positions. In one position the axis of the torpedo is in the line of motion; in this case the angle of entry is unchanged and the initial dive is determined by the angle of entry only. The position in which the axis makes a less angle with the surface of the water than the angle of direction is the position ordinarily obtained in practice; it is caused by the resistance of the water acting upon the head of the torpedo as a fulcrum. The torpedo is shown in the other position where the axis makes a greater angle with the surface of the water than the angle of direction, and in this case the angle of entry would of course be increased and the torpedo would quickly reach a great depth.

RELATION OF ANGLE OF ENTRY TO INITIAL DIVE.

Angle of Entry.	Average Dive.
13° to 15°	9 ft.
15° to 17°	11¼ "
17° to 18°	15 "
20° to 22°	17⅓ "

VI.—DEFLECTION.

The horizontal deflections sometimes observed when the torpedo strikes the water may be due to vibrations of the tube and its mountings set up by discharge. The greater the height of the tube the greater the deflections.

TABLE No. I.

WHITEHEAD TORPEDO DISCHARGE.

Complete Records.

Date.	No. of Torpedo.	No. of Run.	Powder Pressures. lbs. per sq. inch.				Velocity of Discharge.							Angle of Discharge.				Initial Dive.		
			Charge of Powder.	Pressure to start the Torpedo.	Maximum Pressure.	Maximum Pressure developed at	Personal Error to Fire.	Velocity Record commenced at	Time of first Record.	Velocity for 8 feet from first Record.	Velocity for 16 feet from first Record.	Maximum Velocity.	Average Velocity from igniting Primer to the Water.	Height of Tube.	Depression of Tube.	Angle of Entry.	Submerged Angle.	Passed through Net at	Shown by Register.	Maximum Depth.
			3 oz. Sq. Gr. 1 oz. Sp. Hx.				sec.		sec.	ft.	ft.	t.	ft.	ft.						
June 11,	1	17	"	6	18	3″.8	.2	18″	.19			29.3	22.1	6½	3°.5	21°.8		In deep water. struck bottom in 20 Feet.		
" 26,	1	19	"	5	17	3″.1	.34	4″	.17	23.6	29.0	29.0	23.2	6½	4°	21°.6				
Oct. 9,	6	10	"	2	15		.31	8″	.18	28.0	29.7	33.4	26.3	6½	0°	15°.8	8°.2		15 ft.	19 ft.
" 19,	6	13	"	2	19	3″.8	.33	18″	.23	34.7	34.0	34.0	27.5	6¼	0°	13°.8	5°.5	10 ft.	10	11
" 29,	6	15	"	5	23	5″	.24	4″	.17	29.0	32.0	34.0	28.5	10	0°	16°.9	3°.0	7	8	9
" 30,	7	3	"	7	22	4″	.43	2″	.11				28.5	6½	0°	13°.2	2°.8	6	7	7
Nov. 1,	7	5	"		22		.28	2″	.16		30.3	34.0	29.4	7	0°	13°	3°.0	6	9	9
" 1,	7	6	"		21		.37	5 ft.	.29	27.6	30.3	34.5	29.0	10	0°	16°.3	5°.5		10	10
" 2,	7	7	"	5	22	3″	.36	5 ft.	.28	32.0	37.8	37.8	28.8	7	4°	17°.4	5°.5		10	12
" 2,	7	8	"	6	21	3″	.30	5 ft.	.31	33.3	34.5	35.2	29.0	6¼	4°	17°.0	3°.6	8	9	7
" 2,	7	9	"	6	22	3″		1″	.11	27.0	29.0	35.7	28.0	6¼	4°	17°.8	2°.5	6	7	5
" 3,	6	20	"	8	23	3″	.37	5 ft.	.31	40.9	42.0	43.0	33.4	8	6°	17°.4	8°.5	16	10	16
" 14,	7	14	"	6	22	4″	.47	5 ft.	.31	35.8	35.8	35.8	30.0	6½	0°	12°.3	8°.5	16	14	26
" 14,	7	15	"	5	20	5″	.37	5 ft.	.40	29.0	34.0	38.5	26.8	7¼	6°	22°.0	9°.9	18	18	18
" 15,	7	17	"	4	22	5″	.30	5 ft.	.30	29.1	32.8	35.3	28.5	7½	6°	20°.3	5°.5	10	14	14
" 15,	7	19	"	4	22	5″	.27	4 ft.	.27	31.4			29.0	10½	0°	17°	6°.5	12	8	27
" 15,	6	27	"	6	21	4″	.21	5 ft.	.33	26.6	31.4	36.0	27.8	10½	0°	17°.6	7°	13	10	13
							sec.	ft.	sec.	ft.	ft.	ft.	ft.	ft.				ft.	ft.	ft.
				5.2		3″.7	.33	2.7	.23	30.7	33.1	34.7	27.9	7½	2°.3			9½	10	14½

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HONORABLE MENTION, 1895.

A SUMMARY OF THE SITUATION AND OUTLOOK IN EUROPE.

AN INTRODUCTION TO THE STUDY OF COMING WAR.

"Le temps de guerre est arrivé."

BY RICHMOND PEARSON HOBSON, Asst. Naval Constructor, U. S. Navy.

Europe, from the beginning of its history, has been the world's great battlefield.

Few of its generations have passed without engaging in wars of the first magnitude; possession of its soil and predominance in its affairs have ever been contested by rival races and rival nations; but never, in all its belligerent history, has there been, as now, such an accumulation of the forces of war.

A bitterness now exists between the principal western nations that has but few parallels in all history, and never has invasion been so formidable as now, when the Slavonic wave of mountain-like proportion is sweeping westward. Never before has there been such promise of war.

The present generation has grown old, has expended its life in preparation. With the revolutions in the material of war and in the methods of expanding the personnel, time has been necessary for preparation. It has required long and laborious years to evolve the existing engines of war, to organize into armies and exercise under arms all the able-bodied men of entire nations, to perfect the weapons and means of defense, to improve the old and develop the new; but it may be said roughly that now preparation is complete (except with Russia, whose unlimited resources for war, checked only by want of wealth, may be considered as having no limit), for the entire nations *are* organized into armies,

and the uses of the new agents have become more or less defined. Further preparation will be principally in increasing population and increasing wealth. Certainly improvements will continue as always, but they will be, in all probability, essentially improvements, not radical changes like those of recent years.

What may be termed the present order of things military and naval, which is such a vast advance over the old order of things so recently gone out, is now fully established, and will in all probability remain till the test of war.

On the whole, the nations of Europe are prepared, and though Russia is not prepared as she would like to be, to the extent that her population would permit, yet, as will be seen below, she finds an opportunity, a discord in the western family, which gives her an ally, produces an alliance which is not only prepared to accept, but also soon to offer war. There no longer exists the great retarding force of apprehension about the readiness for war. Further, the objects and policies of the nations have become established and clearly defined, except in the case of Italy, to be considered later, and the preliminary alliances have been formed. It only remains with diplomatic strategy to decide on the moment. No fact is so universally accepted abroad as the imminence, the very presence of war. It is a living actuality; not only every man in the armies and navies of the great powers expects to take part personally, but every individual with any hold on life expects to be a witness.

This imminent war bids fair to involve all of the six great nations of Europe, a population of about 324,000,000, of which about 74,000,000 are capable of bearing arms, possessing over 2,000,000 tons of war vessels afloat. In all this population there is burning a strong fire of patriotism, and efforts for putting forth entire strength will be aroused by all the great passions, ambition, hate, revenge, and fear of extermination. The war will be on a scale incomparably greater than any in the world's history.

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The issues will be of a twofold nature, in determining the historic rivalry of the western nations and the equally historic Russian march toward ascendency. The Franco-German struggle promises to culminate by irreparable disaster to the vanquished, as does also the French-English rivalry in African and Asiatic colonization.

The English and Russian rivalry in Asia will be decided forever in case of British defeat, and will be determined for many years to come in case of Russian defeat.

But there is a more far-reaching issue than that of the rivalry of nations. The Slavonic race, the last Aryan race that has arisen in Asia and Eastern Europe, is surging westward. This wave is relatively many fold more formidable than any of the Aryan waves of the past, all of which have ultimately succeeded in supplanting the waves that had gone before and in overthrowing a higher but less rugged civilization.

Recent foresight has led the Russian to cultivate the friendship of France, and has culminated in alliance.

Dissension among the western nations has been taken advantage of, and Russia proposes to drive her wedge home at the moment when France also attacks the other nations. The wedge would be driven home indeed by Franco-Russian victory, for France left alone would be powerless before the surging Russian wave.

So the issue involves not only the perpetuation or the overthrow of the vast British Empire and of the central continental powers, but also the heritage of European soil.

It will determine whether the western civilization, like the high civilizations of the past, has lost the ruggedness adapted to and necessary in this rugged world of ours.

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The study of this imminent war of such colossal proportions, which may alter radically the course of events of the world, is of greatest universal interest. But in addition, for those whose profession is the preparation and prosecution of war the interest is particular and vital, for then will come the first crucial test of the features of the new order of things, military and naval.

Smaller wars in distant lands may throw some light on the conditions of actual battle with modern material, but the conclusive lessons are to be learned only when vast masses of similar material are hurled against each other. In the shock of coming battle alone, when powerful weapons attack strong defense, will the anxious professional eye perceive the relative value and importance of the methods thus far adopted of disposing modern material of attack and defense; from the results of these engage-

ments alone will the tactician be able to deduce the best methods of conducting modern material in battle. Thus, while the universal war will hold the partial fate of mankind at stake, it will at the same time solve the professional problems, insoluble in peace, that the new order of things has thrown out to those whose profession is war, and, above all, to those assigned to naval war.

To the United States before all will these lessons be of greatest importance, for if she has sufficient power afloat during the war to enforce respect for her rights as a neutral, she will become enriched by the expenditures of all the belligerent parties, will fall heir to vast shipping tonnage and world-wide commerce, and will be in a position to begin immediately on her ultimate national and naval policy.

The moment of relative weakness and impoverishment of the other nations will be a rare and vital one for the United States to forge to the front and initiate her natural strong foreign policy, and her naval strength being the means, her naval officers should be instantaneous in deriving the vital lessons for the new order of things to follow.

The coming war, which will give needed and necessary data for every branch of naval science, should thus be made the subject of special study by every officer of the United States Navy. From his own professional standpoint every officer should be prepared, should study the probable conditions, should see the needs and anticipate and, as far as possible, study beforehand the lessons to be learned in his own particular branch.

A necessary introduction to the intelligent study of any particular branch is a general knowledge of the whole subject of which the branch is a part, and he who expects to study a specialty in the coming war should first get a general and comprehensive idea of the war along its broad lines; he should have a general idea of international politics, should understand the sociological forces at work, the historic march and trend of the nations and races involved, should know the attitude of the powers toward each other, the actual alliances and antagonisms that are in existence at the present moment and those that the sociological forces are tending to produce; he should have an estimate of the relative forces, naval and military, present and prospective, of the two sides, with the existing alliances and with those toward which the

forces are tending, and thence deduce the probable and possible course of events, the probable and possible times and characters of war, and the probable issue in each case.

Thus alone can he have the satisfaction that broad and comprehensive knowledge brings, thus alone will he be beyond surprise, prepared for any event; thus alone can he most intelligently and with best results pursue the preparatory study in his own specialty and be ready to learn the lessons of the war, to grasp instantaneously the solutions of the problems in his special branch and to have them ready for the immediate use of his country.

Thus every one who proposes to make a particular study of the coming war should first get a general idea of the situation and outlook in Europe, and a similar idea should be sought by all who take an interest in what is going on in the world, and who wish to look on with intelligence when the coming struggle comes.

A Summary of the Situation and Outlook in Europe.

I.

The development of the means of communication, freedom of speech, and the development of the press in recent years have widely disseminated among the masses of all the civilized nations a knowledge of what is going on in the world. As this knowledge increases, and as the masses realize more and more their power and possibilities, they assume a larger share in regulating the policies of government, foreign as well as domestic. The more the nation rules the greater is seen to become the importance of national interests in deciding questions of foreign policy. The great motor, self-interest, universal in nature, exalted in the masses, is translating itself directly into the councils of government. "Interests" are coming more and more to exclude sentiment, and are fast supplanting the ambition and caprices of rulers and dynasties. Though the forms of government have not greatly changed, the rulers have been coerced, in order to remain a force, into shaping their ambition to the lines of national interest and aspiration.

Where interest rules, power is the sole arbiter. In the councils of nations national power has become the coefficient of national

importance, causing all the nations to tax heavily their resources for the increase of power. Along with the spread of knowledge among the masses there has been a growth of race feeling, consolidation, which has greatly extended the possibilities of the increase of national power. Indeed, national power, the strength of armies and fleets, has come to be measured by the population and wealth. The result has been that the small, poor nations are practically excluded from the councils, since poor nations cannot create and maintain great fleets, and small nations cannot have great armies, so that now the affairs of Europe are regulated by the six great nations alone.

The increase of strength, and its consequent advantages, due to concerted action, applies to the family of nations as to the household of a single nation, and consequently the nations tend to group themselves and combines are formed for mutual benefit.

Thus the advent of "interests" has caused the affairs of Europe to be regulated by only the few great nations, and has caused these few to divide into groups, while it has largely eliminated the uncertain elements depending on the personal traits of rulers, causing thus a great simplification in the study of international politics, with a promise of fruitfulness hitherto impossible.

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In the grouping of nations, coincidence or similarity of interests is the great natural regulator, tending toward becoming exclusive as "interests" tend more and more to dominate.

National interests are: (1) commercial advantage; (2) ambition for extension of sway, for expansion of territory and colonies; (3) sentimental interests, chiefly passions, the chief among which is hatred, race and national hatred (with Russians there is an additional religious sentiment or fanaticism); (4) self-defense. Ambition and passion are integrals or summations of the aspirations and animosities of the nation down its historic march.

In general terms, all of the nations have more or less conflicting aspirations in African colonization, particularly Great Britain, Germany, and France.

For commercial advantages, all the nations would tend to combine against Great Britain, the monopolist. But commercial advantage, though steadily growing in importance, has not been and still is not the dominant factor, at least in the grave

questions of war and peace. Ambition and self-defense against ambition control where national life is at stake, as it will be in the coming war.

Two nations of the six are ambitious, the other four are not. Great Britain, Germany, Austria-Hungary, and Italy are contented with the present boundaries in Europe. France and Russia are discontented and wish to change them. Ambition and lack of ambition thus divide them into two groups. Self-defense against ambition gives the same grouping, with the exception that Italy, who has no fear of immediate aggression (though she should have for ultimate aggression), would, from her geographical position, become a spectator.

In general terms, the nations without ambition have had their passions as well as their ambitions satisfied in modern history, and wish to perpetuate peace to afford opportunity for internal development, to allow free competition for the markets of distant lands, to have amicable understanding about the colonization of unoccupied countries, while the two ambitious nations have had their ambitions thwarted or find them still unsatisfied, and have had their passions fanned by recent defeat. Thus the discontented and ambitious nations are essentially aggressive, while the contented nations without ambition are essentially passive.

Russia, with her great ambition for expansion, is checked in southeastern Europe and in Asia by Great Britain. French ambition in North Africa and in Asia is likewise checked by Great Britain, while all down history British expansion has steadily been largely at the expense of French colonies, and the French race, peculiarly susceptible to passion, has inherited toward Great Britain an accumulated hatred, profound, uncompromising, radical, that has no parallel except in Rome and Carthage.

The Russian frontier presses hard on Germany and Austria-Hungary. The German frontier presses hard against France, whose ambition has been trodden on. Toward the German, and in particular toward the Prussian, the Frenchman has a bitter, inherited hatred, fanned to white heat by shame at recent defeat. Thus Russia, with insatiable ambition, and France with ambition and passion, are in complete accord and form a natural alliance for aggression against Great Britain and Germany, who would be naturally allied in defense.

Peril from Russia causes Austria-Hungary to seek alliance with Germany, though this alliance involves France as an enemy, from whom there is ordinarily no fear of aggression, while France willingly accepts Austria-Hungary as an enemy while it secures a stronger alliance with Russia.

The natural alliances for Europe would thus be Russia and France for aggression, Great Britain, Germany and Austria-Hungary for self-defense against aggression.

Italy's ambition and passion have been satisfied in modern history, though she has naturally desires for Austrian territory and territory in Northern Africa, and, it may be, for some French territory also; yet on the whole she is contented while the process of unification is working within. Her geographical position and freedom from real danger of immediate aggression combine to mark her a spectator.

Thus Europe, in its natural condition, would present the six nations, five in two alliances, the sixth a spectator. This would be the aspect for subserving *immediate* interests, and toward it all the forces are at present tending.

If, however, *ultimate* interests were consulted the scene would change. Five nations would flow together and enlist all their weaker neighbors, to offer one undivided front of self-defense against Russia, whose ambition, read from facts and in history, does not stop short of two continents.

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But causes have countervened the natural grouping, not only in view of ultimate interest, still but vaguely foreshadowed, but also in view of immediate interests. It is only very recently that "interests" have come to be dominant. Great Britain is not allied with Germany and Austria-Hungary, and Italy does not hold the position of a spectator.

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Austria-Hungary and Germany, early realizing a common danger from Russia, formed in 1879 a secret alliance of defense. When France had rallied from defeat, the extraordinary measures for increasing her national strength were taken in Italy to be a menace, and upon the French occupation of Tunis, frightened at the representation that France had unfriendly designs, Italy joined Germany and Austria-Hungary in the Triple Alliance of

defense, with the object of maintaining peace in Europe. This alliance was proposed in 1881 and adopted in 1882, signed in 1887 and renewed for six years in 1891.

France and Russia have only recently fully recognized their remarkable community of interests in Asia and in Africa, as well as in Europe. Only as recently as the Crimean War, France through sentiment joined a natural enemy against Russia, her natural ally, but Cronstadt and Toulon mark their coming together in the strong bonds of common interests. The Dual Alliance, a stable and natural one, is now a universally recognized fact in European politics.

Great Britain is pre-eminently the power whose foreign policy has been steadily directed by national interests, without a tinge of sentiment. Looking over the earth, she early perceived the rich fields beyond Europe, and set her ambition on colonial expansion, with an eye to the commercial advantages that colonies offer the mother-country. A steady, unswerving colonial policy, command of the sea and race aptitude have so far furthered commercial enterprise that she has outstripped all the other nations in the race for foreign markets, and, owning the bulk of the world's shipping, stands without a rival the great commercial monopolist. Having kept a naval force sufficient to overwhelm the force of any probable enemy, and knowing that her islands are free from invasion as long as she controls the sea, she has naturally, being sufficient unto herself, adopted a policy of isolation with respect to continental politics, except where her colonies and commerce are concerned, and has been able to spare herself the heavy burden of standing armies that weighs down the continental powers, devoting her energies and her vast wealth exclusively to the maintenance of her power by sea. Thus isolation has been her natural policy, notwithstanding her community of interest for defense with the central continental powers, even where she considered the possibility of an alliance against her. Even now, facing the formidable Dual Alliance, she sees her power superior to theirs combined. However, on account of differences and coincidences in the shipbuilding programmes of the three countries, an inevitable moment is fast approaching when the strength of the allied enemies will be greater than her own, when she cannot longer lay reasonable claim to the control of the sea. Her enemies being aggressive,

this moment will be one of supreme danger. Isolation then, as far as reason can be applied to probabilities, would be fatal; its voluntary continuation would be rash madness; its advantages, hitherto unaccompanied by danger, will be subordinated to self-defense, which will then be paramount to all other interests. Moreover, this moment of weakness will coincide with the time for the renewal of the Triple Alliance. Italy's interests are setting heavily against such renewal, and a powerful motive against her continued adherence will be the danger of sharing in defeat. If Great Britain joined, this danger would be removed. She would find refuge, and, at the same time, would save Italy, who, after withdrawing, would not improbably go over to the other side. As the day approaches, forces will set stronger and stronger toward her joining, but as yet the indications are slight, and Europe now presents the spectacle of the Dual Alliance of France and Russia drawn up for aggression before two distinct enemies, Great Britain and the Triple Alliance of Germany, Austria-Hungary and Italy.

II.

What should be looked for from such a situation in Europe? When should war be expected? From what quarter will it probably come, and what will be its probable course? The aggressor of course is studying all the possible plans of attack. He will naturally choose, having the choice, the time, method and circumstances most advantageous to himself. The key to the future thus lies with the Dual Alliance, in the study of the best plans for it to adopt.

The best way to attack two enemies is to attack them in turn. The best way to begin an attack on a compound enemy is to disintegrate him. Can the Dual Alliance attack either enemy without the participation of the other? Can the Triple Alliance be disintegrated? The probable events to come are contained in the answers.

Russia is casting glances over the territory south of her frontier along its whole extent. She longingly covets that portion shutting her off from the Mediterranean, and long since would have possessed it had not the western powers interfered. Frightened at the thought, they have steadily opposed, in council and in war, the conquest of Turkey. If now Russia, with France come over

to her side, were victorious in continental war, no sea power, no power under the sun, could prevent the immediate conquest of Turkey; and France, with the same object of striking a blow at the English occupation of India and Egypt, would aid Russia in an invasion of Asia Minor, Persia and Syria. Nothing could prevent the Russian frontier from pushing southward over Roumania, Servia and Bulgaria, over Turkey in Europe and Greece, from crossing into Asia Minor to girdle the Black Sea and sweep down through Syria to circle the eastern shores of the Mediterranean, from pushing down from the Caucasus to spread around the base of the Caspian Sea and reinforce the wedge pointing and already entered toward India. Egypt would fall from the hands of the English and India would follow at a not distant day. With the central powers defeated, all the prodigies of English valor would be powerless to prevent this Franco-Russian conquest. Great Britain, therefore, would never remain a spectator to Franco-Russian victory on the Continent. Consequently, in attempting to defeat the Triple Alliance first, the Dual Alliance would have to engage Great Britain also. To attack the continental enemy would be to attack both enemies.

But if the insular enemy were first attacked, would the continental enemy enter? It would be suicidal indeed in the Triple Alliance to remain spectator and see the Dual Alliance come into control of the sea. Italy, with her long coast lines, would withdraw post-haste and put in a plea to the enemy; but even if she remained, the power of the enemy, already preponderant, would soon become irresistible. The defeat of Great Britain would thus be fraught with the greatest dangers, yet the probability is that the Triple Alliance would remain spectator, for the treaty compact is essentially one for defense only. If, during the conflict between the Dual Alliance and Great Britain, the tide began to set in favor of the former, Italy certainly would not consent to go to war; self-defense *should* cause Germany and Austria-Hungary to enter without her, but the indications point to their remaining aloof. The Triple Alliance acknowledges no obligations to Great Britain, and there are even elements blind enough to relish being spectators to the defeat of the power which rivals and interferes in their colonization and commercial enterprises, and which has steadily considered itself self-sufficient enough to decline all overtures from the Alliance. Further, the Czar (now

the late Czar) is undertaking to draw closer the frontier powers, particularly Germany, the directing head of the Alliance, by commercial concessions, to increase the commercial relations between them and Russia, which, when vast and important, form the best of guarantees against a rupture of peaceful relations; and these overtures are being favorably received and reciprocated, notwithstanding the fact that their unquestionable motive is to draw bonds around the continental enemy to hold him fast while the insular enemy is being disposed of. The probabilities thus point to the non-interference of the Triple Alliance.

Furthermore, there are decided advantages for the postponement of the conquest of the Continent. There are growing elements of disintegration and of internal disaffection at work in their enemies, and an entire accord and unity of purpose within themselves, and it would be surer to engage Great Britain before Italy withdraws, for this withdrawal would open the eyes of the English, and it is not improbable that Great Britain would thereupon join panic-stricken Germany and Austria-Hungary in a new consolidated Triple Alliance, which would offer a formidable front of resistance to attempted aggression.

After the overthrow of Great Britain and the disintegration of the Triple Alliance by the withdrawal of Italy that would follow, the conquest of Germany and Austria-Hungary by the armies whose strength would remain unimpaired by the sea struggle, would be an easy task, whether Italy joined in the conquest or remained neutral, or even if, as is against all probability, she renewed the Triple Alliance.

Egypt and India would then fall like ripened fruit, almost without struggle, and Europe, Asia and Africa would be at the feet of the conquerors.

Thus the best plan for the Dual Alliance to accomplish its schemes of universal conquest is, to first overthrow the British power by sea, then to conquer the central continental powers.

The invasion of the British Isles from the Continent is impossible while the British fleet controls the approaches. It was impossible for the great Napoleon himself, who found in this fact his bitterest experiences. The presence of the central powers, all equipped on the frontiers of France and Russia, would prevent the dispatch of troops against Egypt and India. The struggle, consequently, will be essentially by sea, while the integrity of the armies destined for the continental powers will remain intact.

When will the issue probably take place? At the time most advantageous for the aggressor.

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In the days of sail power and wooden hulls, before the differentiation of types, when all vessels were on an equal footing for defense, and, when sizes were not too disproportionate, for offense also, naval strength was fairly estimated by aggregate tonnage, or even by numbers of vessels, admitting, as is always necessary in investigations on this subject, that unknown elements of personnel are equal. At the present day, however, the protection and destruction of defenseless shipping and commerce is assigned to vessels whose powers of combat are small. Consequently, a large portion of the tonnage and a still larger proportion of the numbers of vessels, particularly for the commercial powers, cannot enter the combats that will decide the issue of struggle by sea. Being outside of the sphere for which they are built, with inadequate protection and inferior powers of offense, they would, if they entered, meet wasteful destruction, without inflicting appreciable injury. It can be assumed that unarmored tonnage will not appear in decisive combat except in an auxiliary rôle.

The life of vessels built of metal is long, being about one and a half times as long again as the average life of man, and the development in naval construction is rapid, being without a parallel in the encyclopedia of progress. Navy lists are consequently swelled with the names of vessels in a good state of preservation, now obsolete, of inferior value, which cannot enter a rational estimate on an equal footing with vessels of recent date.

In broad lines, sufficient for the present purpose, the armored tonnage, on which the issue of naval engagements will depend, can be classified as standard armored tonnage and armored tonnage of inferior quality. Inferior tonnage will avoid engaging standard tonnage for the same reasons that unarmored tonnage will avoid engaging armored tonnage. Consequently, the first series of engagements, those on which the nations' hopes will be centered, will be between fleets of standard tonnage. The standard tonnage that survives will be of enhanced value, if repairs are sufficiently prompt to enable it to enter the subsequent engagements between inferior tonnage. Inferior tonnage has its greatest value where standard tonnage is equally matched with the probability of mutual destruction.

Armored cruisers, a type of recent, wide development, are included in the estimates of inferior armored tonnage, for, though destined in the first instance to engage inferior cruising tonnage, they could figure well in the subsequent fleet engagements between inferior armored tonnage, and, with the choice of time, of position, and of method of attack insured by superior speed, could, in certain instances, find advantageous employment in the destruction of inferior battle-ship tonnage.

Coast defense vessels of recent date are entered in the class of standard tonnage, as the probabilities are that the engagements will take place within their radius of action.

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The relative naval strength of Great Britain is advancing by oscillations. The present moment finds it at the upper limit of a swing, caused by the completion of the programme of the great Naval Defense Act of 1889. It will begin an immediate descent on account of the failure to lay down new vessels during the execution of this programme. The descent will be sharp and sure, the lowest point being reached in 1896 and early in 1897, before which date, practically no addition will be made to armored tonnage, the bulwark of naval strength. On the other hand, the naval strength of both France and Russia is on a rising curve, whose rise is steady, rapid, sure, and presents no point of inflection.

At the present moment* the British naval force musters 261,690 *standard armored tons;* the Dual Alliance musters 215,952 tons, 144,470 French and 71,482 Russian. The British estimate includes the Royal Oak, Revenge, Repulse, and Barfleur, of the Naval Defense Act. The French estimate includes the Brennus and the Jemmapes. The Russian estimate includes the Navarin and Gangut. The line for standard tonnage is drawn in the British estimate at the Colossus and Edinburgh, launched in 1882, the Conqueror and Hero, of date of 1881; in the French estimate, at the Caïman class, the earliest of which, the Terrible, was launched in 1881; while all the vessels in the Russian estimate are subsequent to 1886.

In *inferior armored tonnage* the British force is now 350,590 tons, while the force of the Dual Alliance is 245,812 tons, 155,186

*The following estimates were made in the summer of 1894.

French and 90,626 Russian. The British estimate includes 52,930 tons of coast defense vessels. 253,730 tons, including all the coast defense vessels except the Rupert, carry muzzle-loading guns. Of the total, 56,000 tons are armored cruisers, the Aurora class, the Impérieuse and the Warspite. The French estimate includes 43,146 tons, and the Russian estimate 36,836 tons of coast defense vessels, a total of 79,982 tons. This coast defense tonnage includes modern armored gunboats, 8 French of 11,327 tons total, and 2 Russian of 2984 tons total. All the guns carried are breech-loaders; but, on the other hand, 75,615 tons of the French contingent have wooden hulls, placing them somewhat at a disadvantage of defense on account of shattering and splinters and fire. Of the total, 19,900 tons are armored cruisers, 6200 French (the Dupuy de Lôme) and 13,700 Russian.

The coast defense vessels included in this estimate are mostly of old date, having a very small radius of action. The probability is that the engagements between the fleets of inferior tonnage will take place beyond this radius of action. The comparison of forces will consequently be more accurate by the elimination of coast defense vessels from both sides. The British inferior armored tonnage, without coast defense vessels, is 297,660; that of the Dual Alliance is 165,830, 112,040 French and 53,790 Russian.

The mean date of launch of the British standard armored tonnage is 1888, while that of the Dual Alliance is 1886, that for France being 1885 and that for Russia 1889. The average British standard ton is two and a half years (two years and four months) more recent than the average ton of the Dual Alliance. This lapse in an epoch where development and improvement have been so rapid guarantees a marked superiority in *quality*.

The mean average date of launch of British inferior armored tonnage is 1873, while that of the Dual Alliance is 1876, that of France being 1877 and that of Russia 1874. The average inferior armored ton of the Dual Alliance is three years more recent than the average ton of Great Britain (the dates do not change whether coast defense vessels enter or are eliminated). Progress was less rapid at this epoch. Three years insure a superiority of quality, but not so marked as the same lapse would insure at a more recent date.

All the armored cruisers are of recent date and of high speed

and great coal endurance, and, having great resulting strategic superiority, would be at a marked premium over the average inferior battle-ship for the subsequent engagements. Here, in armored cruiser tonnage, Great Britain preponderates by 36,100 tons.

Thus, at the present moment, Great Britain has for the first series of engagements with the Dual Alliance a superiority of 45,738 standard armored tons, the average ton being of a superiority of *quality* guaranteed by two and a half years of rapid progress. For the subsequent series of engagements she has a gross superiority of 104,778 inferior armored tons. Eliminating coast defense tonnage, she has a superiority of 131,830 tons, though the *quality* of the average ton is inferior by three years of progress at the epoch of twenty years ago, though this inferiority, due to later date of average launch, is offset by a superiority due to an excess of 36,100 tons of British armored cruisers.

Thus at the present moment British force by sea preponderates over that of the Dual Alliance for the first series of decisive engagements in the proportion of 1.21 to 1, and is of marked superiority of *quality*, while for the subsequent series of engagements the proportion is 1.79 to 1 (coast defense tonnage being eliminated).

It would be folly for Russia and France to precipitate the conflict now. Immediate war need not be expected.

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What are the prospects for the future? Will the Dual Alliance find a more advantageous moment when its force will equal or preponderate over that of its enemy? What will be the additions to the strength of both parties? What will be their relative strength when British force passes down from its present maximum to its coming minimum in 1896-97?

The first battle-ships to be added to the British fleets are the Renown, Magnificent, and Majestic. The first of these to be added, the Renown, would go in commission early in 1896, in the ordinary course of events; the other two would come later. Supposing that construction is hastened, and that the Renown can be added by the autumn of 1896, the addition would be 12,350 standard armored tons. The Magnificent and Majestic cannot be hoped for before late in 1897. In the meantime,

France will add the Tréhouart, Bouvines and Valmy, the Jauréguiberry, Charles Martel, and Lazare-Carnot, and, by accelerating construction, the Masséna, and, possibly, the Bouvet, an addition of 78,356 standard armored tons; and Russia will add the George the Victorious, the Three Saints, and, by accelerating construction, the Sevastopol, Petropolovsk, Poltava, Admiral Senyavin, Admiral Ushakoff, and the Cisoi-Velikie, an addition of 72,802 standard armored tons, making a total addition for the Dual Alliance of 151,158 tons. The strength of the two parties in standard armored tonnage will then be: Great Britain 274,040, the Dual Alliance 367,110; 222,826 French and 144,284 Russian.

In *inferior armored tonnage* Great Britain will make no additions. Russia will add the armored gunboat Otvajuy, of 1492 tons, and France will add the four armored cruisers of the Charner class, 18,696 tons, of most efficient quality.

Admitting that the Renown will be launched in 1895, and that the average date for the vessels to be added to the force of the Dual Alliance will be 1894, the mean launching date of British standard armored tonnage in 1896 will still be 1888, while that of the Dual Alliance will become 1889, that of France being 1888 and that of Russia 1891. The mean date of launch of British inferior armored tonnage will remain 1873, while that for the Dual Alliance will become 1878. Thus, toward the close of 1896 and early in 1897 the Dual Alliance will have for the first series of engagements with Great Britain a superiority of 93,070 standard armored tons, while its average ton will be of more recent date (about ten months) than the average British ton. The British inferior armored tonnage will still be superior by 111,642 tons (coast defense vessels being eliminated as before), though its average date of launch will be four years and two months earlier than that of the Dual Alliance, and its value will depreciate from the fact that the probability points to the survival of a considerable force of the standard armored tonnage of the enemy after the first engagements.

Thus, though the British force now preponderates over the force of the Dual Alliance for the first series of decisive engagements in the proportion of 1.21 to 1, it will witness in 1896-7 a preponderance of the enemy in the proportion of 1.34 to 1. At present the British inferior armored tonnage would find the seas clear of hostile standard armored tonnage after the first series of

engagements, and could throw in to advantage in the subsequent series of engagements its heavy preponderance in the proportion of 1.79 to 1; but in 1896-7 the first engagements would leave hostile standard armored tonnage to impede and overcome the British inferior tonnage preponderating in the proportion of 1.6 to 1. The average British standard ton, which is now two years and four months more recent than the average standard ton of the Dual Alliance, will in 1896-7 be ten months older. The average British inferior ton, which is now three years and one month older, will in 1896-7 be four years and two months older.

Thus both preponderance in quantity and superiority of quality, which now belong to the British fleets, will pass over by 1896-7 to the fleets of the Dual Alliance.

This situation will be inevitable. No armored tonnage resulting from the scare and crusade of last fall and winter can enter in line before late in 1897, no matter how great the urgency, and the Majestic and Magnificent, as mentioned above, a total of 29,800 tons, will come too late for the moment of relative weakness. Great Britain will inevitably see a preponderance against her of 93,070 standard tons, more than one-third of her entire standard armored tonnage.

Every indication points to her enemy's seizing this unhappy moment to make the attack. It should be made, as stated above, before the expiration of the treaty compact of the Triple Alliance in 1897, in order to insure Great Britain's being left alone. There is no doubt that France and Russia both appreciate the situation. The extraordinary activity in the shipyards of both countries has undoubtedly one common concerted object, to enable the Alliance to seize the rare opportunity which both powers have vainly longed for, but which no nation has yet had since Nelson bequeathed to Great Britain the control of the sea.

The non-interference of the Triple Alliance being guaranteed, the odds will be heavily in favor of the Dual Alliance, notwithstanding the traditional valor and skill of British officers and seamen, and notwithstanding the preponderance still of British inferior armored tonnage, for defeat in decisive engagements of the first series, between standard armored tonnage, with hostile standard tonnage still surviving, can never be redeemed afterwards by inferior tonnage.

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After the defeat of Great Britain, the next step in the plans of the Dual Alliance will be the conquest of the central powers. The first step toward this conquest will be the disintegration of the Triple Alliance. To effect this, Italy's burden under the alliance is being made as heavy as possible by French financial policy. Italy will be threatened against remaining, will be allured to withdraw, and tempted to cast her lot in with the Dual Alliance. There can be little doubt, as will be seen further, that she will decline to renew the treaty alliance on its expiration in 1897, were Europe to remain as it is. If, in addition, the fall of the British Empire precedes, the imminent danger from the threatening victor would do away with any hesitation. She would certainly withdraw to isolation. France and Russia would then make overtures for her joining them, requiring a light burden, guaranteeing certain victory, and offering rich rewards in the division of spoils, which would be the more acceptable that they would be largely at the expense of her old enemy.

Italy having withdrawn, the struggle with Germany and Austria-Hungary would be essentially on land. If Italy remained neutral, France and Russia would offer for invasion, at the present moment, 1,416,000 men on the peace footing and 6,630,000 on the war footing, against an opposing force of 856,400 men on the peace footing and 4,380,000 men on the war footing. This heavy superiority will be greater in 1897, for the aggressors have a population of 165,000,000 in entire accord to draw from, while Germany and Austria-Hungary have but 91,000,000, with dangerous elements of discord growing day by day. There would be no need of delaying for further weakening of the enemy, for the working of socialistic disaffection in Germany, and the race dissensions in Austria-Hungary, and the serious seeds of disloyalty sown by Slavic influence in the eastern divisions of the Austro-Hungarian army. The Dual Alliance could march to the conquest with entire assurance on the morrow of British defeat.

If Italy joined in the conquest, the unhappy powers would be invaded from the south as well as from the east and west by an additional force, numbering about 259,000 men on the peace footing and about 2,000,000 men on the war footing.

Should Italy, against all her interests, against all probability, remain with the Triple Alliance, the conquest would involve a fierce struggle by sea as well as by land. The fleets of the Dual

Alliance would return shattered from the destruction of the British fleets. Time would have to elapse before they could be sufficiently reinforced. It would not require long, however, for the armies of the Triple Alliance are coming to absorb all the resources. The navies for new construction receive less than one-third of what the Dual Alliance now appropriates, and the disproportion will become greater and greater as Italy is ground down lower and lower under her financial burden, and as the elements of disaffection work in the German nation. The armies are now nearly balanced, with a slight preponderance on the side of the Dual Alliance. The preponderance, for the reasons already mentioned, will grow steadily larger each year. The inevitable conquest of all three central powers would follow not many years later. Nothing could save the Continent after the overthrow of British power by sea.

The next step in the plans of the Dual Alliance, the conquests beyond Europe, would be practically achieved. No serious opposition could be made. They could be taken possession of at leisure. The day France and Russia, after British overthrow, look up from the battlefields of Austro-German defeat, they will see their frontiers start on the march across southeastern Europe, into Africa, into Asia. There will be no serious obstacle in the way of this march toward the circumference of three continents, not even the walls of China or the deserts of Africa. The conquering powers would control the Eastern hemisphere.

Such are the best plans for realizing the highest possibilities opened up to France and Russia by their alliance, and the probability is that such, in the main, are the plans they have concertedly adopted. An unforeseen event might, however, precipitate a conflict between the Dual and the Triple Alliance against the wishes of the former. If it came at the present moment, the Dual Alliance on land would throw for the first wave 1,416,000 men against 1,115,000, and a total of 6,630,000 men against 6,380,000 men. On sea, it would send 215,952 standard armored tons to engage 218,749 standard armored tons, equal fleets, which would mutually destroy each other and clear the seas of standard tonnage. Then it would send 245,812 inferior armored tons to engulf 120,722 tons. Each year of postponement, for the reasons mentioned above, will mark a heavier and heavier preponderance for the Dual Alliance. For instance, in 1896, on the sea, the

standard armored tonnage, at present about equal, will stand 367,110 tons for the Dual Alliance and 235,791 for the Triple Alliance, the inferior armored tonnage being 266,000 and 131,382 respectively.

The probability would thus point more and more strongly to Franco-Russian victory; but when the tide began to set this way, Great Britain, for the reasons stated above, would enter. Throwing into the struggle, at the present moment, 261,690 standard armored tons, in 1896 274,040 standard armored tons, without mentioning inferior armored tonnage and the armies to disembark on the Continent, she would turn the tide of victory to the other side.

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If no such unforeseen event occurs, and if the Dual Alliance neglects to seize its opportunity of 1896, leaving events to take their ordinary peaceful course, Italy will in all probability decline to renew the Triple Alliance treaty in 1897.

Germany and Austria-Hungary should be indissolubly united by common danger, but Italy is held with them solely by the incorrect assumption that France has designs against her and that French preparations are a menace; whereas the advantage to France in her real designs on her eastern frontier, and to the Dual Alliance, accruing from not having to divert or immobilize an army corps on the south, would be so great that every guarantee would be given against aggression if Italy would withdraw. All of Italy's interests are set against her remaining. The burdens, the expenditures required, and the commercial and financial policy of France, are already causing ruinous financial distress, which is entirely unnecessary. It is her natural, geographical prerogative, not yet appreciated, to reap alone the incalculable benefits of neutrality in the event of general European war. Her natural policy is that of isolation. She has nothing real to fear from either of the parties to the war, and no interests of hers conflict with theirs. It is true, as stated above, she would not object to an accession of territory from Austria, her old enemy, though now her ally, or even from France, particularly in northern Africa, yet her ambition for the present is satisfied while the process of unification and amelioration continues within. Further, a black, ominous cloud has recently risen above the horizon. She joined Ger-

many and Austria-Hungary sure of perpetuating peace, to form an alliance that France could not dream of attacking. Now, however, France has found an ally and the Triple Alliance no longer is a guarantee of peace, for the Dual Alliance musters a strength that already preponderates, particularly on the sea, where Italy is most exposed, and whose preponderance is advancing with enormous strides. While Italy remains in the Triple Alliance, without British assurance, she faces the grim spectre of defeat. She would never have joined, she will probably not remain, in a Triple Alliance which has the Dual Alliance for an enemy.

Deserted by Italy, Germany and Austria-Hungary would lie helpless. In 1897 their 113,786 standard armored tons and 82,293 inferior armored tons would disappear like a breath before the 367,110 standard armored tons and the 266,000 inferior armored tons of the Dual Alliance. Their sea-coast would be ravaged, cities bombarded and ports blockaded against any supplies from without, while the invading armies, the first wave 1,416,000 strong, the total 6,630,000 strong, entering from the east and from the west, would overwhelm the 856,400 men in the first line of opposition and the 4,380,000 total.

The two nations in despair would cry out for British aid, and their cry would probably be heard, for the eyes of the British would be opened; they could not help seeing that the French and Russian armies unrestrained after Austro-German defeat would march unobstructed from Europe to the conquest of Egypt and India, even admitting that the British fleet kept a preponderance of force on sea. On Italy's withdrawal, the probability points to the formation of a new Triple Alliance of Germany, Austria-Hungary and Great Britain, the natural alliance of defense against the natural Dual Alliance of aggression. This Triple Alliance, formed on the expiration of the old in 1897, would oppose 387,826 standard armored tons and 432,883 inferior armored tons, against 367,110 standard and 266,000 inferior tons, about an equality in standard armored tons and a heavy preponderance in inferior armored tons. Great Britain, with her resources, could probably maintain an equality, if not a preponderance, by sea, though it would be a sore burden, as she would have practically no assistance from her allies. But the situation on land would remain hopeless. Assuming that the British troops would be

found on the battlefields, the alliance, if now formed, would oppose in the first wave of war 1,075,800 men against an invading force of 1,416,000 men, and a total of 5,035,000 men against 6,630,000. This heavy preponderance will become greater each year, and ultimately would inevitably become utterly overwhelming, for the population of the one, 129,000,000, is increasing at the mean annual rate of .88 per cent., while the 165,000,000 of the other is increasing at the mean rate of 1.33, and this latter vast population does not count a dissenting voice in taxing its vast resources to the utmost, while the lesser population contains dangerous internal elements of division and weakness.

The withdrawal of Italy and the formation of the new Triple Alliance nevertheless would not probably be a signal for immediate war, though, as seen above, equilibrium would not exist. The aggressors would wait to allow the weakening elements of the enemy to work their way, recognizing their own strengthening unity of purpose. Italy would be offered inducements that would outweigh the advantages of spectatorship and neutrality. As mentioned above, the Dual Alliance would require but a light burden and would offer rich rewards. In the certain partition of Germany and Austria-Hungary that would follow she would be promised vast tracts around the Adriatic which, in the hands of an old enemy, have long been looked on with covetous eyes, and France, with vast, gratifying accessions on the east, might offer the old provinces of Nizza and Savoy, and might, perhaps, allow her to take Tunis and Tripoli, being sure herself of getting Egypt. With a certainty of victory, and fear of displeasing the powers that would, without her even, be victorious, she would probably pass from isolation to alliance. Europe would then see the six nations in the two great natural Triple Alliances: France, Russia and Italy for aggression; Germany, Austria-Hungary and Great Britain for defense.

Impatient aggression would not then have occasion to wait longer for further weakness in the enemy, having a preponderance on the sea of more than 100,000 standard armored tons, and, taking the present condition as an index, though each year will make a greater preponderance, on land an excess of 600,000 men for the first wave and 3,600,000 men total excess. This preponderance would be overwhelming. Signing the new aggressive alliance would sound the bugle-call to war. Europe would be

seized with convulsions. Three nations would be engulfed in one great upheaval. Germany and Austria-Hungary would no longer be seen on the map; the British Empire would belong to past history.

It is evident which nation of the three victors would claim the East and take the largest share of the West. After the wrangle, a new era would begin in Europe. Its duration and its termination are easily seen. A glance at the map of history and the march of events shows that Russian ambition does not stop short of two continents, and will not be satisfied till Russian territory has no boundaries but oceans. After their intoxication, France and Italy would awaken in a nightmare; they would rush to alliance, but too late, they would be as children against a giant. A glance at the populations and their rates of increase leaves no hope for western civilization in its birthplace. Its young offspring across the ocean would be left alone to contest the high seas and redeem in part this error of history.

If, however, against probability, Italy renews the Triple Alliance treaty in 1897, Great Britain having continued isolated and the Dual Alliance having neglected to seize the opportunity offered in 1896-7, continuing thus the present status, the goal of the two races will still be not far off. The race by land is already practically won. The Dual Alliance can maintain preponderating armies guaranteeing victory with comparative ease, while the larger part of the increase of tax on the resources of the two nations would be devoted to the great race with Great Britain for preponderance on the seas. As seen above, it will be ahead in the race in 1896-7, at which moment both races will be won if it has the hardihood to bring them to a finish; but in 1898-99 the British fleets will reap the harvest sown in the last scare. Adding the Magnificent and Majestic and the seven new nearly similar first-class battle-ships laid down this year, seven of the nine in 1898, the other two in 1899,* a total tonnage of about 135,000, while the French add the Charlemagne, the St. Louis, and, by acceleration, the Henri IV., and a similar battle-ship not yet named, a total of 43,000 tons, and Russia adds one battle-ship similar to the Three Saints, and two similar to the Cisoi

* A more recent programme reports ten of the Majestic class, five to be completed in 1897-98, and five in 1898-99; also six of about 6000 tons to follow shortly after.

Velikie, a total of 30,250 tons (Russia will add two powerful armored cruisers similar to the Rurik, of more than 12,000 tons each, which will make a heavy addition to inferior armored tonnage not here considered, since no addition will be made by the other powers), making a total for the Dual Alliance of 73,450 tons, about 61,500 tons less than the British additions, reducing the preponderance held in 1896-7 of 93,000 tons to 31,500 tons. The Dual Alliance thus will then still be ahead, with the chances of victory on both elements.

After 1898-9, beyond which estimates cannot now be made, the probability points to the Dual Alliance maintaining the preponderance, notwithstanding the vast resources of Great Britain and the intention of the British to maintain their force on a par, for, judging from the appropriations which have become enormous in France and Russia (in 1892 France provided for nearly $200,000,000 to be expended on new construction within ten years), it is the intention to tax to the limit the combined resources of the two nations. Consequently, when next year the French and Russian naval strength catches up with the British strength, the two races may be considered won whether the winner chooses war then or later.

III.

The future is thus gloomy for the essentially passive powers, whether the Dual Alliance has the boldness to adopt the most favorable plan or whether it awaits the ordinary course of events, which would probably consolidate the enemy. Is there any escape from this gloomy situation? Are there any methods of thwarting these plans? What can the passive powers do?

The same methods will thwart both plans. The surest and most desirable, the best method, would be the formation of a quadruple alliance of the passive powers, to take the offensive without delay. The force of this new alliance would heavily preponderate; on sea it would engulf the enemy. To accomplish this method, Great Britain would have to renounce her policy of isolation, which she is loth to do, and the treaty would have to embrace an offensive element, which would in all probability meet strenuous opposition from all the signatories. This method may consequently be considered as practically impossible.

The second best method would be for the Triple Alliance,

though feigning defense, to take the offensive without delay. As seen above, the force of the Dual Alliance preponderates, though by land the preponderance is small; but, in case of adversity, British aid could be depended on, and the war would become general, as it would by the first method. But the treaty compact of the Triple Alliance is essentially one of defense only, particularly as far as Italy is concerned; consequently voluntary offense cannot be hoped for. Only by some unforeseen happening, causing the Dual Alliance to take a premature offensive attitude, could this method be realized.

There was some hope afforded by the attitude of the German Emperor last year,* in his determined efforts to strengthen without delay his own army, in his visiting both allies to review their forces, in his assembling his forces for their autumn manœuvres on the fields from which they will advance to battle, and in the tenor of all his utterances touching military affairs. It seemed that he recognized the situation, penetrated the future, saw the advantage, the necessity of action without delay, and was making preparation for bringing about the great issue. But subsequent events have dispelled this scanty hope, particularly the favorable reception of the Czar's overtures for commercial reciprocity.†

The third best method would be for Great Britain to take the offensive without delay. The Dual Alliance would be loth to accept the engagement in view of the advantages of postponement, particularly cool, calculating Russia, and it might be difficult to find a pretext; but there is always the open Eastern Question, and, with France, the question of African colonization, while among the French nation there is an over-confidence caused by the vista opened up during the exultations of Cronstadt and Toulon, which could no doubt be turned to advantage.

It would of course be best for her to attack the enemies one at a time, or one only, if possible. The best method would be to attack France, endeavoring to secure assurances from the Triple Alliance, or at least from Germany and Austria-Hungary, of participation in the event of Russia joining. Then it is not improbable that crafty Russia would decline to enter, notwithstanding her professions of alliance, for, as seen above, the two

* Summer of 1893.

† A similar instance is found in the participation with Russia in interference with the recent treaty of peace between China and Japan.

allies combined would be overmatched by Great Britain alone. On the withdrawal of Russia there would be no reason for further execution of the war, for Great Britain has no fear from France except in her alliance with Russia. This move would effect the dissolution of the Dual Alliance. The eyes of the Frenchmen would be opened and they would renounce all idea of alliance with Russia.

The other method would be to attack Russia, seeking assurances from the Triple Alliance of participation in the event of France joining. There can be no doubt that France would be loyal and join. It is possible, on the other hand, if Russia is attacked on the Eastern Question, so important to Germany, so vital to Austria-Hungary, and then if she is joined by France, whom Italy is learning to hate and has brought herself to dread, that then the Triple Alliance might be induced to enter, notwithstanding the purely defensive nature of the alliance, and the general war so desirable might thus be brought about.

Great Britain stands toward Russia in standard armored tonnage in the ratio of about 3.66 to 1, and in inferior armored tonnage in the ratio of about 3.87 to 1; toward France she stands in standard armored tonnage in the ratio of about 1.81 to 1, and in inferior armored tonnage in the ratio of about 2.26 to 1. No doubt can be entertained as to the issue if either one alone is engaged. If the Triple Alliance joined Great Britain the combined force by sea of the four powers would stand toward the Dual Alliance in standard armored tonnage in the ratio of about 2.24 to 1, and in inferior armored tonnage in the ratio of about 1.92 to 1. The seas would be swept. On land, assuming that the British armies would be on the battlefields, a warranted assumption, since the seas would be clear and the troops would have allied soil to disembark on, the Quadruple Alliance would muster 1,335,000 men on the peace footing and 7,035,000 men on the war footing, while the Dual Alliance would muster 1,416,000 men on the peace footing, 6,630,000 men on the war footing. Considering the dispersion of the Russian army over a vast area and her separation from France, there is no doubt that the armies of the four allies would be found superior on the decisive battlefields.

If Great Britain attacked both parties to the Dual Alliance, a favorable opportunity would be offered the Triple Alliance for

precipitating advantageously the inevitable conflict by land, and the probability points to the war being made general. But should the Triple Alliance decline to enter, and should Great Britain, in attacking one ally, be forced to engage both, even then, as seen above, the issue being essentially by sea, her unaided fleets would still throw a heavy preponderance against the allied fleets, in the proportion for standard armored tonnage, of about 1.22 to 1, and for inferior armored tonnage of about 1.43 to 1. Thus if Great Britain took the offensive without delay, the probability in all the events of war that could follow would mark her as victor, with an assured new lease of the sea and of the world's commerce.

Of the three desirable methods by which the war could be made general, while the passive powers preponderate in force and would act in unity, this one alone offers any grounds for hope. But this only hope is very scant, for Great Britain is loth to become a belligerent in European war and is slow to change her policies. With her vast commerce and shipping, she dreams of the riches which would come with neutrality when the Continent, hostile within, seeks its supplies from without, or of the choice of entering late in the conflict to decide its issue, bearing a small part of the burden and reaping a large part of the spoils. She realizes, too, that her daily bread comes over the water, that she would starve if its arrival were stopped for even a short while, and she sees the vast amount of her property that is on the high seas that would be exposed to a maritime enemy. She perceives that she has a monopoly already of the markets of distant lands, and that her colonial expansion continues to overshadow that of all the other nations. She enjoys prosperity and foresees its continuance with peace, and she looks with angry eye on any part that threatens to disturb peace where she might be involved. She would be loth, very loth, to take the offensive; she is slow, very slow, to discontinue her policy of isolation. The maxim has become general that she has all to lose by war. The maxim has not yet spread that she has all to save by war.

The fourth best method, the only one remaining, would be the formation of a defensive quadruple alliance, effected by Great Britain's joining the Triple Alliance without materially modifying the nature of the treaty stipulations.

The forces by land of the two alliances would not largely differ.

The slight preponderance, as seen above, would now rest with the four allies. On the sea, the Quadruple Alliance now has 480,439 standard armored tons against 215,952 standard armored tons of the Dual Alliance, and 471,312 inferior armored tons against 245,812 tons. In the event of war, the fleets of the Dual Alliance would be annihilated and the sea-coasts laid bare and colonies exposed. France could not dream of permitting such a state of affairs, even if she were sure of victory on land. Consequently, offense from the aggressive alliance would be out of the question. Even in 1896-7, at the moment of Great Britain's weakness, the Quadruple Alliance would offer 509,831 standard armored tons against 367,110, and 481,972 inferior armored tons against 266,000. England would in all probability come to the financial relief of Italy, and with her untold wealth could probably maintain a preponderance of force by sea in favor of the Quadruple Alliance, while the continental powers strained their energies to keep the armies on a par. Peace would be insured for many years, and another generation might pass before the conflagration came.

The Dual Alliance, however, would not think of renouncing its passions and its schemes of conquest, and a pitiless, relentless peace struggle would begin on a scale undreamed of even in this day of crushing armaments. There is no doubt that the Quadruple Alliance could maintain a preponderance for many, many years, though in nothing like the present proportion, if all its members bent their energies in accord to that effect. But while in France and Russia there is but one national purpose, without an opposing voice from man, woman or child, in Germany there is a growing socialistic disaffection, in Austria-Hungary there is dangerous internal dissension among the heterogeneous population, and Italy is wailing in financial distress.

The 165,000,000 of souls, united in one purpose in France and Russia, are increasing at the mean annual rate of 1.33 per cent., the 39,000,000 French at the rate of .32 (the mean for 20 years, 1871-91), and the 126,000,000 Russians at the rate of 1.64 (the mean from 1867 to 1886), while the 160,000,000 souls with dissenting voices in the Quadruple Alliance are increasing at the mean annual rate of only .83 per cent., the 50,000,000 Germans at the rate of .98 (the mean from 1875 to 1890), the 41,000,000 of Austria-Hungary at the rate of .76 (the mean from 1870 to 1890),

the 31,000,000 Italians at the rate of .62 (the rate in 1881), and the 38,000,000 British at the rate of .917 (the mean from 1871 to 1891). It is evident which alliance would win the race in growth of armies.

In sea power Austria-Hungary has not and will not figure. Italy is barely holding her own. For new construction her appropriation has passed from $6,500,000 for the year 1890-91, $5,600,000 for 1891-92, $4,900,000 for 1892-93, to $4,900,000 in 1893-94, while it is estimated at $4,900,000 for the current year 1894-95. Germany, straining every nerve for her armies, is neglecting her navy. Her appropriation for new construction has rapidly and steadily decreased from $8,500,000 in 1891-92, $6,900,000 in 1892-93, to $4,600,000 in 1893-94, and it is estimated at $3,300,000 for the current year 1894-95. On the other hand, both France and Russia are making steady, unparalleled additions. The French appropriation for new construction has risen from $11,600,000 in 1890-91, $13,600,000 in 1891-92, $13,600,000 in 1892-93, to $14,200,000 in 1893-94, and it is estimated at $14,800,000 for the current year 1894-95; and the Russian appropriation has risen from $7,500,000 in 1890-91, $9,500,000 in 1891-92, $10,400,000 in 1892-93, to $11,100,000 in 1893-94, and is estimated at $11,000,000 for the current year 1894-95.

The total appropriation of the Triple Alliance (not taking account of Austria-Hungary) for new construction in 1890-91 was $17,900,000, while that of the Dual Alliance was $19,100,000. For the current year the estimates for the Triple Alliance are $8,100,000, a falling off since 1890-91 of $9,800,000, and for the Dual Alliance they are $25,800,000, an increase since 1890-91 of $6,700,000. The excess for the Dual Alliance was $2,200,000 in 1890-91; to-day it is $17,700,000.

The British additions have fluctuated by reason of the oscillatory programmes of construction. The mean annual appropriation for new construction since 1888-89 (the year previous to the Naval Defense Act) has been $21,700,000. For the current year it is estimated at $23,400,000.

Thus the total appropriation for new construction has been somewhat larger for the Quadruple Alliance, though it has been on a constant decrease, while that of the Dual Alliance has been steadily increasing. Preponderance, though in nothing like the present proportion, would no doubt be maintained as long as the alliance remained intact.

Thus the peace struggle would continue till Italy, for the reasons mentioned above, impoverished, if not utterly bankrupt, from the burden laid upon her, fearing the approach of the day of sharing defeat on land with her allies, threatened and allured by the menacing enemy, perceiving the prerogative of her position, withdraws, either to remain a spectator and reap the benefits of neutrality, or to join the Dual Alliance and share the spoils of victory. The day Italy withdrew, equilibrium would be broken, the balance would drop with a thud to the side of the aggressive party. The great war struggle would be at hand, with forlorn outlook.

At first sight this method of postponement might appear to offer an opportunity for allowing time to alter the sentiment in France, to open the eyes of Frenchmen and cause them to abandon the alliance with Russia, and join their brother nations in one united body, to throw out of Europe the universally threatening Slavic race, and restrict Russian ambition to Asia, to the hardy task of supplanting the stagnant races of the East, or of forming a barrier between Europe and those hordes that may some day become warlike, while in peaceful Europe, where a small common standing army could easily defend a single eastern frontier, the brotherhood of the higher nations of western civilization, reasonably adopting universal arbitration, could divert the national resources to the universal betterment of the conditions of life, to regulating the colonization by their own superior races of the unoccupied portions of the earth, and to arranging for humanely supplanting or exterminating, if it is impossible to elevate, the inferior races, to regulating, in sum, in the best way, the affairs of our planet.

But this dream of Utopia is inconsistent in our world of universal struggle, and cannot for a moment be indulged in broad daylight by any one acquainted with Frenchmen, nor to any one familiar with the domestic, scholastic and military education of the French could there be any hope for the coming generation which will not have seen the days of 1870-71. Besides, the alliance with Russia, which, to a spectator, seems so unnatural, is, as stated above, a most natural one to Frenchmen, whose shame and passion hide ultimate interests by immediate ones. There are no doubt moments of calm and reaction in many thoughtful French minds, when undefined questionings come as to what lies

beyond the glorious vista; as to what real fellowship can exist between two types of races, occupying widely different rounds on the ladder of civilization; beween two governments, one of freedom and one of despotism; that after all the affection displayed by Russia, she can care for them only as temporary instruments, coolly using their forces, their generosity, their passions for inexorable plans of conquest that would in next turn take in without hope of resistance their own lovely country, or else might, after the overthrow of Great Britain, principally by French fleets, and the accession of India, sufficient for temporary expansion, abandon France, with her strong passions and thirsts still unsatisfied, and leaving her thus with no rewards except a necessary opening for colonization, which is already larger than the requirements of the nation, weakened by conflict, to stand again alone against the central powers, while she, in her turn, prepared for the great game of European conquest, for the time when the dissenting western nations should cripple themselves and exhaust their forces in war with each other.

But these undefined misgivings or questionings are stifled and would never be uttered for fear of incurring the accusation of a want of patriotism, the most reproachful accusation that could be made in France. No, the only way to dissolve the Dual Alliance is to put Russia to the test of sharing defeat with France. Great Britain alone can apply this test.

It seems hard that France can be saved only by defeat. This great, brave, chivalric nation has suffered for humanity all down history. Defeat at the hands of an old enemy, and the renunciation of the bright hopes for revenge on the other old enemy, would be the severest of all the martyrdoms yet demanded of beautiful France; but the price even then would be small if it redeemed her, and saved her at the same time that it saved Europe from ultimate destruction at the hands of the too powerful young giant, standing club in hand, with threatening and determined brow, knocking at the door of higher western civilization. As seen above, however, there is little hope of this salvation. The hope is somewhat greater, though still small, that the fourth and least desirable method, the formation of a defensive Quadruple Alliance, may be realized. As seen above, the policy of isolation has been a natural one and is a stubborn one with Great Britain, yet the forces will set toward a renunciation as her rela-

tive weakness becomes more and more evident. If the nation could be familiarized with the real relative strength of fleets, estimated rationally by separating standard from inferior tonnage, at the present moment and during the years to come, there is no doubt refuge would be sought in the Triple Alliance, and there would even be a glimmer of hope for her taking the immediate offensive.

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Thus, in conclusion, in studying the situation and outlook in Europe, the dominating fact, towering above all others, is the alliance of the two great aggressive nations, France and Russia, who count more than half of the entire population that regulates European affairs.

Though French aggression is principally from passion, strong, natural, inherited, injured, and only partially from ambition for expansion, while Russian aggression is almost wholly from ambition for expansion and but very slightly from passion and fanaticism, yet both aggressors aim at the same enemies. The overthrow of Great Britain and the conquest of Germany and Austria-Hungary would satiate even French passion, while the consequent opening up for expansion over central and southeastern Europe, over Asia and into Africa, would overflow the banks of even Russia's boundless ambition.

The natural designs of the alliance are stupendous, defying almost the imagination itself. Its possibilities are fairly boundless, covering a hemisphere. If fully realized, they will change utterly the face of three continents.

The feature of the alliance which most imposes itself on the mind of the observer is the formidable force it musters and the amazing rapidity with which this force has recently grown and continues to grow. In the two great factors necessary for great armaments, wealth and population, its resources are fairly inexhaustible, France having the wealth and a boundless generosity toward Russia, and Russia having the population. The powers of the Triple Alliance, on the other hand, which until recently increased their forces apace, have now lagged far behind. From 1890 to 1894 the entire standing armies of the three allies have been increased by only 71,000 men and the force on the war footing by 320,000 men, while the French and Russian standing

armies have been increased by 139,400 men and the force on the war footing by the enormous figure of 1,330,000 men. The aggregate appropriations for additions to the naval forces of Germany and Italy (the small appropriations by Austria are not considered), during the last four years, amount to $43,600,000, while those for France and Russia amount to $98,200,000. Thus the total additions to the land forces have been in the proportion of 3.76 to 1, and the total appropriations for additions to the naval forces in the proportion of 2.25 to 1, and each successive year has seen the disproportion between the additions become greater. The additions to the strength of the Dual Alliance are steadily increasing, those of the Triple Alliance are steadily decreasing. The maximum strength of the latter has been reached, its resources are taxed to their limit. The maximum for the former is not yet in sight, and as far as can be seen has no limit. The stationary force has now already been passed by the one that continues to advance with great strides; each day sees the gap between them widen, increases the probability and the disaster of defeat.

Great Britain, during the last four years, has appropriated for new naval construction $87,200,000, $11,000,000 less than the Dual Alliance. She intends, no doubt, to maintain a force as far as possible equal to that of the two allies combined, but, as explained above, the different methods in the shipbuilding programmes of the three countries and the coincidences, concerted or unconcerted, in the times for laying down new vessels, cause the British force to be now at a marked maximum of strength and to approach an inevitably low minimum in 1896-7.

On examining further into the internal condition of the two parties the sight becomes alarming. Distressing division exists among the passive powers and becomes more distressing each day. Great Britain is isolated, and Italy, in financial distress, tends strongly toward withdrawing from alliance with Germany and Austria-Hungary. Germany is rent internally, and prevented from developing her whole strength by disaffection, identified more or less with socialistic growth, the outcome to a large extent of the burden imposed by a heavy armament where, after victory, there is not the offset of active incentive or burning passion. The military bill last summer was a symptom. It required the dissolution of the Reichstag and the use of all the influence of the

sovereign over a most loyal nation to procure its passage. Austria-Hungary has internally, in the dissensions of its heterogeneous and widely different races, all the elements, indications and symptoms of dissolution, and Russian influence is undermining the loyalty of the Slavic element of the army as of the population.* France and Russia are standing closely united before an almost hopelessly divided enemy.

To darken still more the gloom of the horizon, the passive powers, dedicated to peace, oppose taking the offensive themselves and will allow the aggressor to choose his own time and method of attack. The present is supremely the opportune moment for the passive powers; a future time will be for the aggressors, who are now crying out peace, peace. This cry of peace means "Peace till my weapons are sharpened," while the passive powers appear blindly to think that it means enduring peace, a contradiction to the very nature of the two powers and their alliance.

Fate or forethought will have the Franco-Russian strength reach its maximum preponderance over British strength previous to the expiration of the treaty of the Triple Alliance. Italy will, in all probability, have decided not to renew the alliance though still being in it, which will prevent the shaking up of the powers and the formation of a new natural Triple Alliance, thus depriving Great Britain of the chances of having German and Austrian aid, while, in all probability, she would, on the verge of disastrous war, applying at the eleventh hour, be refused refuge in the Triple Alliance.

After Great Britain's overthrow and Italy's withdrawal following it, Germany and Austria-Hungary would be an easy conquest, whether Italy chose to join with the conquerors or not.

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On examining further into the events to follow the fulfillment of the aggressors' stupendous designs, whether realized easily as just indicated or by one of the other probable ways previously discussed, the situation takes on an awful aspect.

How would the spoils of three continents be divided by France and Russia?

*Recent reports have it that Austria-Hungary has been induced by arguments or threats into taking steps towards abandoning the alliance with Germany, her natural alliance, her only possible hope.

The population of France is less than 39,000,000; that of Russia more than 127,000,000. The French population has been increasing over a lapse of fifteen years (from 1876 to 1891) at the mean average annual rate of only .32 per cent.; the Russian population has been increasing over a lapse of twenty years (from 1867 to 1886) at the mean average annual rate of 1.64 per cent. The Russian population is thus nearly 3¼ times as large as the French, and is increasing four times as rapidly. (During the last fifteen years the rate of increase in France has been on a steady decrease; it had fallen from .500 in 1876 to .065 in 1891. At the latter rate Russian increase is twenty-three times as great.)

French temperament is and has long been strongly opposed to colonization. The Frenchmen who leave France usually return. France does not care for large increase of colonial territory, and would be content with but a small share of German territory, while Russia is steadily expanding at a rate not approached by Rome when she was advancing to her conquest of the world.

For the coming war, passion dominates in the bosom of the Frenchman, who is looking for revenge; ambition animates the Russian, who is looking to extension of Slavic sway.

Thus it is evident that to Russia would fall the vast territory on two if not on three continents.

If Italy should sit at the feast of victory, which she may do, she would be satisfied and well pleased with a comparatively meagre morsel of the spoils, a modest part of the territory now belonging to Austria and some territory in Africa.

After the feast, France and Italy would perceive that they had waged the fratricidal war in the interests of a power, then ready, inevitably, after a short time, to swallow them also, both at a time or singly.

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To check this sombre, onward rush of events there are no means on which much hope can be placed. The great, best remedy, the dissolution of the Dual Alliance, does not permit hope. This alliance, founded on complete community of immediate interests, is come to stay, and is growing stronger and more indissoluble each day. Only disastrous war, realized or imminently threatening, can dissolve it. No combination in Europe without Great Britain's sea power could threaten or inflict such

war. This sea power at the present moment could do so alone, but the opportunity is rapidly passing away. There is scarcely a shadow of hope that Great Britain will take the offensive; there is but the barest hope that she will throw her power into the Triple Alliance to save herself and it. This Alliance itself, from the very nature of its exclusively defensive compact, cannot, while the Dual Alliance cries peace, take the offensive and insure the later joining of the British sea power in the event of adversity.

Thus the entire responsibility rests with Great Britain, and the necessity is urgent for her immediate action. Each day sees the vessels building in France and Russia nearing completion. Fifteen months hence the preponderance of power will have passed over to the enemy; the Dual Alliance will be beyond the possibility of dissolution; the one opportunity for saving herself and Europe from the dread consequences of this alliance will have passed forever. Each day will then bring nearer the day of her greatest exposure to a stronger aggressive enemy; each day will render less probable her acceptance into the refuge of the Triple Alliance; each day will render more inevitable the desertion of Italy and her passing over to the enemy.

If self-sufficiency, or conservatism, or want of enlightenment, or of foresight, or lack of decision, or boldness, or all combined, cause Great Britain to neglect the call of duty from the crisis in her own and in the world's history; if she fails soon to throw her fleets against the enemy, neglecting to choose war while she is stronger and while the enemy could be disintegrated, leaving the enemy to choose it when he becomes the stronger and indissolubly united, and if she fails also to adopt the less desirable but only other alternative of seeking refuge in the Triple Alliance in time for acceptance and in time to save Italy, thus leaving the road clear for the plans of the great aggressive alliance, then may Heaven prepare to come down on earth to work miracles by the hands of men, may a host of guardian angels hover close over freedom and civilization as they tremble in the lands of their birth.

"LAGUERRE."

DISCUSSION.

LORD GEORGE HAMILTON.*—A perusal of the pamphlet entitled "An Introduction to the Study of Coming War" is very interesting to an Englishman, as giving the views and deductions of an outside authority upon the present and future strength of the British Navy relatively to that of France and Russia. The writer has treated the subject entirely from a statistical and arithmetical standpoint, arbitrarily dividing ships into two categories, "Standard armored tonnage" and "Inferior armored tonnage." He treats every ton of each class as an equal fighting unit and then makes up the totals of these units. On this assumption he draws wholesale conclusions very much to the disadvantage of Great Britain. In my judgment, this method of gauging the fighting power of a fleet is fallacious, even if the classification were sound. To take a large number of ships varying in size from 12,000 to 6,000 tons, and of every conceivable shape, some turret, some barbette, some high freeboard, some low, some heavily armored vertically, others relying on horizontal armor, and to assume that every individual ton of every different ship represents an equal fighting force is a self-evidently erroneous proposition. But the classification of what is "standard armored tonnage" and what is "inferior" is also faulty. If the age of a ship is to be the governing factor as to whether it is "standard tonnage" or "inferior tonnage," the age of a ship must date from the time she is laid down, and not from the date of her launch. British vessels are built and completed much more rapidly than foreign vessels, and this celerity of construction is as remarkable before launching as afterwards.

A vessel has merely to remain for a long period on the stocks unlaunched to become, according to the principle of classification adopted, a superior fighting ship to one laid down after her but launched before her. The method, both of classification and addition, adopted operates unfairly so far as the existing fighting power of the British fleet is concerned. As regards the future, the conclusions of the writer are based on inaccurate information as to the condition and progress of the big ships building in the different dockyards of Russia, France and Great Britain. It is assumed that by December, 1896, France will have added seven big battleships to her fleet—Russia eight. To divide these numbers by half is a more correct estimate of the probable state of the ships eighteen months hence from their known condition now. Whilst the two navies above mentioned have their additions greatly exaggerated, a corresponding depreciation is made of the reinforcements of the English navy during the same period. There are now 10 ships of far larger dimensions than are building in foreign yards, in various stages of construction. It is assumed that of these 10 the

* Lord George Francis Hamilton, at present Secretary of State for India, formerly Secretary of State for the Navy, framer of the Naval Defense Act of 1889.

Renown only will be ready by December, 1896, and the Magnificent and Majestic by the end of 1897. The estimates presented to the House of Commons show that the Magnificent and Majestic will be completed by July, 1896, and the Renown shortly afterwards. If the acceleration of the remaining seven vessels became of real importance they would, one and all, be completed by the end of 1897.

The idea that Great Britain is in a trap for the next two years is an illusion. Whilst criticising the general principle advanced in this pamphlet, the contentions entertained in it are very valuable to Naval Administrators, as evincing the necessity of a continuous and uninterrupted addition year by year to a fleet of those big fighting vessels upon whose numbers the supremacy of the sea alone depends

Captain H. C. TAYLOR, U. S. N.—It is not easy to discuss Mr. Hobson's essay in a brief or superficial manner.

He is very sweeping in his arguments, and they are so ably sustained as to deserve an amount of thought and study scarcely to be looked for in any ordinary criticism or discussion.

Logically Mr. Hobson is correct; the conditions he lays down are those that appear to exist in Europe at the present time, and the deductions he draws from their existence are accurate. Nor can we say with any positiveness that his forecast of the future situation may not be confirmed within the next quarter of a century.

The difficulty with such problems as these, which occupy so wide a field of thought, is that no matter how logical the reasoning may be the premises upon which our logic is based may themselves be defective, and for the reason that with ordinary human discernment we cannot recognize all the growing national influences now existing unless they have attracted our notice already by visible action and striking effects.

Among the students of modern history there are some who claim to perceive in southeastern Europe a nascent force which promises to be for centuries to come a thorn in the side of Muscovite dominion. The national spirit now stirring there, unnoticed save by a few, may include the states of Servia, Bulgaria, Roumania and the adjacent principalities. The nation thus formed would be the natural heir of the Turk in Europe and of Austria-Hungary's eastern provinces, and its extension to the north and northwest would, in a measure, depend upon the degree of exhaustion of Russia and Austria in the next great European struggle.

This budding state would command the outlet of the Black Sea and dominate the Adriatic and Levant. Its youthful vigor would utilize to the fullest extent the great military and naval strength of the Balkan peninsula, whose strategic qualities have been almost forgotten by the decrepit government of the Sultan. The opportunity and signal for its birth would be the outbreak of those mighty conflicts which our essayist clearly discerns in the near future.

This empire of the Balkans, or by whatever name it shall be known in history, will be always on the flank of Russia's westerly advance across

Europe. Its strategic position will compel her anxious attention in case of war. Something more than an army corps will be needed to contain or observe the army of the new state and to mask its influence in the theater of war. It must be attacked directly and by Russia's principal armies, which in so doing must expose their flank to western Europe. Its fleet will not be so easy to prepare as its armies, for the nucleus of the latter exists already. Its naval strength once developed, however, would be exerted from a position of great strategic value in the event of a determined contest between the Dual and Triple Alliances. Details are purposely avoided, for it is not claimed that immediate war would find this nationality sufficiently crystalized for action; but should some years elapse before the deciding blows are struck its influence will probably be felt. Our first answer to the essayist's question of what is left for the passive powers of Europe to do against the impending onrush of the Gaul and Muscovite would therefore be that England and the Triple Alliance should devote their skill in diplomacy to encouraging those southeastern states to prepare for union, independence and a strong army and navy, and to educating them to understand their future destiny as a factor in European affairs.

There is yet another latent force in Europe which, if developed into activity, would exert a powerful influence upon the situation as described by Mr. Hobson. This force is Spain, if it shall once awaken from its long sleep. The elements of greatness exist in Spain to-day. The national spirit has been at times subdued but never destroyed. Signs of its revival are apparent to those who examine closely. Commerce and industries begin to develop at Barcelona and elsewhere. It has already the nucleus of a respectable army and navy and is developing ambitions as to Morocco. Should this revival continue and prove to be solidly based we should soon have to take into consideration the excellent strategic situation of the Iberian peninsula.

Knowing that Spain is not dead, but only sleeping; recognizing her compact and isolated nationality, we ought always to expect a future renewal of her greatness. It is probable that such a renewal would be marked in its earlier stages by the absorption of Morocco, the strengthening of her posts in the Balearic Islands and by a rapid increase of army and fleet. We can easily imagine in such a contingency how strong would be the influence at sea of this reviving power in the western Mediterranean, and how hazardous it would be for French armies to undertake distant campaigns against the Triple Alliance while hostile Spanish columns awaited in the passes of the Pyrenees the signal to advance upon Bordeaux and Toulouse.

In further reply, therefore, to Mr. Hobson's inquiry as to what the passive powers can do, I suggest that they can encourage Spain to absorb Morocco and to strengthen her military and naval force. England can assist her finances, now much involved, and her industrial development.

Spain can in fact be put upon her feet by the passive powers and her developed strength and exceptional strategic position would weigh too heavily in the scale to be disregarded by any combination.

Spain then can be made very quickly a powerful clog upon the wheels of the Dual Alliance, while with longer time for naval preparation the Balkan empire or republic might become an almost impassable obstacle in the path.

These suggestions are not put forward to controvert Mr. Hobson's arguments, but to introduce other elements in the discussion which perhaps have a place there and which may modify somewhat the conditions of his problem.

It is doubtful if in any case events would move as rapidly as the essayist believes. It takes much time to overcome the spirit of nationality, even after a nation is subdued and overrun. If the years in the essay were decades and decades were centuries it would seem to some members of the Institute a reasonable forecast; for when we think of the past history of these countries and note how irresistibly the waves of Eastern nations have moved westward across Europe until their force has been spent, it is natural to believe that in the future this phenomenon may be repeated.

Commander C. F. GOODRICH, U. S. N.—The writer has given, to help us, in speaking of the elements of naval force, some definitions which will doubtless meet with general acceptation, for they express tersely what would ordinarily require long verbal circumlocutions. His *standard* and *inferior armored ton* are indeed welcome terms. I could wish that he had suggested a similar happy measure for *quality* of armored tonnage. This is implied, but not so clearly stated as it must have been in his own mind.

I think this essay an ingenious speculation in European politics, although I am unable to accept its postulates or its conclusions. There is, so far as I know, no evidence of a wave of Slavonic invasion sweeping westward as argued. Indeed, the late Czar will be longest and best remembered for his steady and successful determination to preserve peace at all hazards. His successor's policy is not likely to be greatly different, for his attention will be largely compelled to internal questions.

The writer's apprehension of immediate war seems to be based on Russian desire for territorial aggrandizement, aided by French thirst for revenge. It is not improbable that cool heads in Russia have not yet forgotten how difficult and relatively fruitless was the war with Turkey in 1878. There is nothing in the history of that campaign to show the possibility of equipping and putting into the field a tithe of the total available force now borne on Russian paper. It is but fair to subject all similar estimates to equivalent reductions, leaving, of course, the relative numbers about as stated. The absolute numbers I am not in a position to verify, nor is their truth, which is not questioned, essential to the main contention.

That Russia covets Constantinople, and that she will eventually obtain it, is doubtless correct. But this indicates a specific, not a general, scheme of expansion. The same holds good for the eastern outlet which

she seeks, with due pertinacity, in Korea. The invasion of India is a movement she cannot undertake at the same time with either of the other two; nor does it, at any moment, offer much chance of success against the large and well trained force in India of British Imperial and Indian troops. Personally I have never understood the fear expressed and felt by many Englishmen on that score. Judicious handling of the Afghans will secure an efficient buffer on the western frontier of India, while a glance at any good map will make clear the slight hope of victorious advance toward Peshawur from the northwest.

Egypt is not to be taken from England's grasp by any army however strong until her command of the sea is destroyed. Now naval warfare is not entirely a question of numerical contrast. Lord Nelson was always willing to fight the French even when they were slightly superior in numbers. And he was right, as the battles of St. Vincent, Aboukir and Trafalgar testify. There can be no doubt in the minds of disinterested critics that the sea habit of the English will always give them a decided advantage over the French, with tonnage, armor and guns equal. We can readily compare numbers, but to evaluate *morale* is no light matter. The persistent keeping of the sea, the constant, never-ceasing drilling and manœuvring of squadrons have fitted the English to enter into their next naval war with a confidence born of practical familiarity with their weapons.

It is stated that in 1896-7 the Dual Alliance will have, in standard tonnage, 1.21 ton to England's 1.00. Apart from the difficulty which France and Russia would encounter in effecting a junction of their fleets, this proportion should occasion no paroxysm of alarm to Englishmen, who have fought and won against as heavy odds. After all, I feel confident that those who guide the destinies of Europe are well aware of the great possibility of defeat, even when somewhat numerically superior to England, and that they will be slow to risk a naval campaign on an equation where two and two do not necessarily make four.

One matter is omitted from this very thoughtful essay which appears to me vital. Of course, such numbers as 1,416,000 to 856,400, to be followed by a total of 6,630,000 to 4,380,000, are not to be taken *au pied de la lettre*, but rather as indicating a rough proportion between what will, confessedly, be huge and opposing masses; but, after the most liberal allowance made for exaggeration in these estimates, there will remain armies of a magnitude almost inconceivable. The question at once arises, how and by whom shall these armies be supported and supplied? The days of living off invaded country have passed away, and so money for these suggested enterprises must be found. France might raise enough for her own needs by national subscription, although the interest charge in her annual budget is already appalling in size, and national schemes are less popular than before the days of Panama. But Russia is poor and must go to the Jews. Will they advance the requisite cash? Herein opinions may properly differ. Mine is that such a request would meet with a firm and final refusal.

It appears to me that the existence of a Russian wish to overrun

Europe first and the rest of the Eastern hemisphere afterwards is stated rather than proved. Without the absolute certainty of Russian co-operation France will sigh in vain for *revanche*, Alsace and Lorraine, and probably our cousins across the water, while keeping a careful eye on the weather, can, for a time yet, sleep peacefully, undisturbed by dreams of universal war, and this notwithstanding the hatred of the Frenchman for the Englishman—far greater than that he bears towards the German—and notwithstanding, too, the menace to peace in the complications likely to spring out of the Simonoseki Treaty.

Mr. W. LAIRD CLOWES.—With respect to the interesting paper of Mr. Richmond Pearson Hobson I should like to say that the author appears to take a far too pessimistic view of the situation in Europe. It is true that everything points to the probability that sooner or later the Triple Alliance must break up, and that we shall witness alliance and co-operation between those fellow-Latins and natural allies, France and Italy; but, on the other hand, I cannot admit that the unnatural pact between France and Russia is likely to continue. The fate eventually reserved for Russia seems to be isolation, in Europe at all events. Nor does the writer take a sufficiently rosy survey of the progress of the British naval preparations. He says that the Magnificent and Majestic, for example, cannot be hoped for before the end of 1897. I hope that we shall see both of them in commission before the end of the present year, and that the Renown and at least one of the still newer battle-ships will be ready next year. At the same time I grant that we are not going ahead as fast as considerations of prudence should dictate, and that unless we accelerate our rate of progress we stand in danger of sooner or later falling out of the race with the Dual Alliance. Yet, believe me, we shall put on the necessary spurt in time. We are not situated as you, our cousins, are. We have no large inland territories which can only with the greatest difficulty be induced to realize the value and importance of a strong navy. All our population is quite solid upon that one question if upon no other. We do care for that point; but I don't think that we care much for the European situation, save so far as it may directly affect or threaten our immediate interests. Nor do we, I think, dream of European alliances. There is only one alliance, a strictly anti-aggressive one, that would be really popular here, and that is an alliance, in the interests of general trade and peace, of the whole Anglo-Saxon race. Mr. Hobson does not touch upon such a consideration as a possible factor in the moulding of the world's future. It is nevertheless a consideration which is forcing itself before the attention of thoughtful men on both sides of the Atlantic. The man who, on your side, hasn't traveled fifty miles outside Hugginsville, and the man who on our side hasn't traveled fifty miles outside Little Peddlington, won't listen to a suggestion of such a consummation; but these are not the gentlemen who direct affairs, thank God! Every Englishman who spends a few months occasionally with his hospitable American cousins, and, I hope and believe, every American who either

comes here or who travels a bit about the world and takes intelligent notice of what his race and ours has done and is doing, sees whither the common interests are drifting. You have cut loose from the home strings, and certainly no one here blames you for having done so; yet, although you have cut loose, you have the same ancestry and the same blood, and may heaven give you one day a part in the common inheritance, in defense of which I look to see all our kin ere I die stand together. Surely we can both observe and cherish our national allegiance without forgetting, in the stress of honorable rivalry, that we owe some racial allegiance as well. If only every Briton could see the United States, and every American could see the British Empire, the petty and passing jealousies of the two great branches of the family would be quickly swallowed up in a desire for co-operation and mutual help and in generous pride in the family prosperity.

Lieutenant C. N. ATWATER, U. S. N.—To those interested in the study of the world's politics from a military standpoint the vigorous and novel views set forth by the essayist are worthy of attention. Probably few officers will entirely agree with these views. It is safe to say that a majority will find that they are extreme. But a debt of gratitude is due the essayist for opening up, as a new subject of discussion for the Institute, the treatment, from a naval standpoint, of international politics. While articles of a character similar to this one abound in the British reviews, they are conspicuously absent from periodicals on this side of the Atlantic, and in breaking ground in what is for us a new field the essayist turns a furrow both broad and deep. It would seem to be a duty for the handful of commissioned officers of our army and navy—thirty-five hundred of the seventy millions of our population—to discuss and to keep discussing the war politics of the world. They are the nation's only trained technical students in military matters, and when questions vast enough to involve the welfare of the whole civilized world are at stake they should have opinions as to what the possible results may be.

The essayist refers to the rare opportunity the coming war will offer the United States to take her place among the world's carriers and attract wealth to herself instead of paying heavily to get her goods to foreign markets. Then, indeed, will she "be in a position to begin immediately on her ultimate naval policy . . . if she has sufficient power afloat during the war to enforce respect for her rights as a neutral." But is she likely to have such power when it is needed? Is she not more likely, if things move as usual, to be ready to get into difficulties at the moment when a decisive stand, backed by force, would secure her freedom to reap whatever benefits an armed neutrality might confer? Weakness may even force her to take part as a combatant in the struggle, for her children are not patient when put upon. As a foreign writer has recently said, "The Americans are known to act regardless of consequences." Admitting that the affairs of Europe are in a desperate condition, that condition may mean more of danger than of

profit for us. We are not ready for war. We are rich and relatively defenseless. Why may not the overburdened Continent, laying aside its differences, create a diversion by attacking and despoiling us? We, like our European neighbors, are controlled by interest, and our interests clash with theirs to our betterment. They certainly do not love us enough to fight for us, and that some of them would enjoy seeing us humbled there can be but little doubt. The United States alone among the great nations can afford to consider military power as of secondary importance, but even she cannot safely assume that she may not be forced to fight. With her millions of aggressively patriotic citizens ready to cry war with a sure voice whenever there is a show of provocation, she should reflect, when she interferes in the affairs of the nations, whether her forty thousand soldiers and sailors are strong enough to enforce her demands and ensure her safety. If she cannot be content to stand modestly back from the front rank of the powers, she should lose no time in preparing for war by strengthening her fleet and the defenses of her waterways and coast cities.

The essayist has quite a startling array of figures marshaled in support of his views as to what may happen abroad, but it is questionable if the preponderance of the fleet of the Dual Alliance will be as great in 1896 as it is made to appear on paper. The value of other than battleships is not sufficiently emphasized, while such other factors as fortified coaling stations, torpedo fleets, merchant tonnage, the supply of trained seamen and the possession of great wealth are either not dwelt upon or not mentioned. If, indeed, Great Britain hesitates to ensure her sea power by spending upon it a larger proportion of her enormous wealth, at the same time that the Dual Alliance continues to advance in fleet building, it may be foreseen that she runs a risk of losing her sea power somewhere in the twentieth century; but that she will neglect to provide against the danger does not seem very probable. Those who have been expecting the outbreak of the "imminent" European war ever since Russia and Turkey came to blows over the Eastern Question have little faith in predictions as to when it will begin, what will cause it, or what sides will be taken by the nations concerned.

It seems to me that the essayist has allowed himself to make a bugbear of the Slavonic race. He is so earnest that he occupies the ground of those English Russophobes who find it necessary to alarm their countrymen in order to secure money for the defense of the empire, and he goes even farther than they do, for where they see menaced a single nation, and that their own, he regards the whole civilization of western Europe as in danger. He seems to see issuing from Russia's vast territory barbaric hordes, like unto those of Attila or Timour, which must inevitably flow over Europe to the destruction of the liberties, arts and sciences which go to make up our civilization. But modern Russia is not really a spectre before whose unmeasured and superhuman power the West need tremble. Her barbarism is rapidly giving way to the western civilization she is supposed to threaten, and if she changes the present political boundaries of Europe it will not be to lay waste the nations with fire and sword.

As lookers-on we Americans have neither bitter animosity nor overheated affection for any outside nation. As the essayist points out, interest rather than sentiment controls modern policy. Among our naval officers Russia will find her champions as against England, France as against Germany, and the reverse is equally true. Individual officers may prefer one nation to another, but as a class we champion no power but our own.

Asst. Naval Constructor HOBSON.—The paper above was prepared in the spring and early summer of '94. Since then an international event of the first magnitude has taken place: a war has been entered into, prosecuted and concluded.

History presents few cases of war—the gravest phenomenon that takes place on our planet—where the consequences promised to be more grave, more far-reaching. Apart from the vast economic, sociological and ethnical vistas opened up, in which speculation loses itself, the political situation and outlook in Europe have been profoundly influenced. A power has been added to the list of Russia's enemies, which acts with tremendous leverage on Europe.

Japan has finally closed the war under such circumstances that no fact is so universally recognized as the approach of an inevitable struggle with Russia; on this fact the eye of the nation is centered, and with it in view, the national policy will be shaped and the national resources plied.

Moreover, a strong fleet, being the first essential, will be the first aim of the policy. This fact is of capital importance to Europe, whose immediate destiny hangs over the sea, wrapt about by the British fleets; for henceforth Russia must maintain in the Pacific a squadron superior to the entire Japanese fleets.

Whether the additional vessels are furnished by Russia alone or by Russia and her allies together, the result is the same, they are so many vessels diverted from Europe, wholly lost to the possibility of action in European waters, where the great engagements are to take place.

The Chinese and Japanese fleets, now combined under the Japanese flag, will retain in the Pacific all the Russian and French vessels sent as reinforcements during the war; and during the accomplishment of the extensive programme of construction entered on by Japan, as each new vessel hoists the Japanese flag, an equivalent must weigh anchor from Cronstadt, Brest or Toulon and bid farewell to Europe.

This loss has cut down seriously the possible preponderance of the available fleets of the Dual Alliance over those of Great Britain, and after a few years, when the English and Japanese harvests, now sown, are reaped, it will be practically impossible for the fleets of the Dual Alliance in Europe to maintain an equality with those of Great Britain.

The war has thus produced an effect equivalent to the addition of a new fleet to the British fleets, and the addition of a new nation with vast and willing resources to the British nation in the effort to create and maintain a naval superiority over the Dual Alliance.

As a consolation for the universal regret felt when European influence caused Japan to recede from her conquests only to clear the way for Russia, it should be borne in mind that the renunciation of continental territory and restriction to water-locked possessions will throw Japan's aspirations more toward naval affairs. The foundations are laid for a great naval power, which will be the greater for not having continental possessions to divide the national mind and national treasury. In consequence, the bulk of the war indemnity and of the price paid for the renunciation of territory, and the bulk of future appropriations, will flow to the creation of a new navy, as did the war indemnity from France to the creation of a new German army.

This result is far more advantageous to Europe. It is better for the present that Japan's resources should flow to naval power to call away Russian vessels than that they should flow to military power to divert Russian troops from Europe.

Those who were inclined to criticise the British non-interference in behalf of Japan will come to recognize that no break has been made in the wise counsel that has steadily guided British foreign policy.

Thus, in sum, the war in the East, the rise of Japan, has come at an opportune time to enter a lever under the scales of political Europe, to sustain them from toppling under the weight of the great aggressive alliance.

In order to enter with a preponderance of strength into the struggle for the first great object of their ambition, the overthrow of the British empire, France and Russia must now look to the result of their overtures to Italy, whose bond with the Triple Alliance will soon be loosed. If Great Britain, through the peculiar, substantial inducements that she could make with her wealth and her fleets, can secure and guarantee Italy's neutrality, or, if she enters an alliance with her, Europe will be guaranteed against Russian victory, and, as will be seen below, since Russia has more interest in waiting than in engaging in uncertain war, a new guarantee of peace would be given and impatient France would be doomed to longer waiting.

The creation of a naval power in the East, dedicated to enmity to Russia, has come to the rescue of Europe. The rise of Japan as a rival and aspiring power will call a larger share of Russian attention to Asia, where lies the great field of her legitimate ambition.

Russia has been held up to the gaze of the world, and the chances are somewhat better that all the nations may come to realize that she is the universal enemy. Such a realization might throw Russia into Asia, save Europe, and set our planet right again, leaving the great struggle of the races to be fought under fair conditions, which would end in the elevation or else in the extermination of the lower.

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The criticisms in the interesting and valuable discussions above are of two kinds: technical, relating to the estimates of naval strength; and general, relating to what may be termed the Russian question. The

first takes issue with the method employed for determining naval strength, and challenges the results; the second doubts the existence of a Slavic wave, or doubts the seriousness of the question, or sees the possibility of the growth of new modifying factors. Other criticisms are parts of or attach themselves to these.

A navy or a fleet, being made up, being the resultant of the combination of a number of vessels, any process that deals with the qualities of a fleet or navy must be a numerical process. The strength of a fleet or navy is derived from the strengths of the individual vessels. Though the strength attributable to any vessel will vary with the combination of vessels, the strength of the combination is essentially distributed among the individual vessels, a loss of any one of which must entail a certain loss to the combination. The strength of a fleet or navy being thus essentially the aggregate of the quotas of strength of the individual vessels, any process or method for determining the strength of a fleet or navy must be essentially arithmetical.

The value of any element for prosecuting war lies in its capacity for inflicting injury. The measure of the value of a fleet or navy is its power to inflict injury. The power to inflict injury will depend on what may be termed the innate power of the agent and on the opportunity for the exercise or use of this power. This opportunity depends on the strategic conditions or circumstances resulting from three kinds of elements, from what may be termed the innate strategic elements, depending upon the relative innate powers, from what may be termed the natural strategic elements imposed by the necessary positions of advantage or disadvantage, and from what may be termed the human strategic elements. The human elements of strategy can never be determined beforehand, and even where previous experience or record gives grounds for presumptions, these should not enter into estimates similar to those proposed. The natural elements of strategy will have a profound influence in determining the results of the possible and probable sea struggles of the nations of Europe, and should be separately and specially considered in drawing ultimate conclusions. For the purposes of the paper and for the present purpose, the natural and human elements of strategy are eliminated by the assumption of equality, so that, whether it is a question of individual vessels, of fleets, or of navies, the second factor for determining the value or strength, the opportunity to use innate power, is assumed to depend only on innate powers themselves. Thus restricted, the problem of the estimation of naval strength resolves itself into two parts, the evaluation of innate power, and the opportunity of advantage or occasion of disadvantage resulting from the relative powers in the case in question.

The innate power of a vessel is composed of two elements, the power of her weapons, and her ability or power to use them. Moreover, these two elements enter as factors; either of them would be useless without the other. The final exponents of the two, however, are not the same, for the element of offense, in its silencing effect on the weapons of the enemy, enters as a part of the element of defense, and its final exponent will in consequence be greater.

Let a rapid mental process make a rough evaluation of the two elements or factors, offensive power and defensive power, for a typical vessel of each of the recent types, assuming, as this does, that the vessels are within their radii of action; let the factors be held up apart, though with the multiplication sign between them, with unity as the exponent of each factor, if the imagination finds it difficult to picture an exponent greater than unity for offensive power, and let the products stand opposite. Examine the column of products. Passing down from the battleship to the coast-defense the difference is moderate, but from the coast-defense vessel to the armored cruiser the difference is enormous; the armored cruiser and the very large protected cruiser peculiar to the British navy do not differ largely, but between them and the ordinary cruiser there is another enormous gap; passing down through the cruisers to the gunboats and torpedo vessels and torpedo boats, the difference continues more or less regularly.

What do the two gaps in the column indicate? They indicate that the vessels on different sides are so different in power or force that a necessary assumption of equality in the human element of strategy will forbid them engaging each other, except where the conditions are such as to force the weaker. Moreover, this gap cannot be spanned by superior numbers. A vessel on the higher side engaging any number on the lower will always possess that strategic advantage of inflicting more injury than she suffers.

If the columns are divided by the tonnage of the vessels in each case, these gaps will be found to be even wider. There will be this difference, however, the very large British protected cruiser will pass over to the lower side of the gap. It is only by virtue of her great size that she can enter the list of the French armored cruisers of less than half her tonnage. If tonnage is the basis, she must go over to the ordinary cruiser side or else enter the other side with a heavy coefficient of reduction. Another noticeable fact is that now the armored gunboat rises up out of its rank and can be admitted even across the lower gap.

Take now the types of vessels of previous decades. The battleships and coast-defense vessels produce products that lie between the two gaps. The cruisers all drop well down below the lower gap.

Thus for all types of vessels, strategy has put up two essential barriers that classification for estimates cannot cross, one that shuts off unarmored tonnage, and one that divides armored tonnage into two parts. When control of the sea is the object of naval engagements, and where both sides possess considerable quantities above the upper gap, the rôle of the vessels below the lower gap must be considered as only auxiliary. These being the conditions of the coming engagements, it may be assumed, as stated in the paper, that unarmored vessels will not enter as deciding factors. Further, the upper strategic gap across the middle of armored tonnage indicates that vessels on the lower or inferior side will not engage voluntarily those on the upper side. It indicates that the first engagements will be between

vessels on the upper side, and the subsequent engagements between vessels on the lower side and what vessels on the upper side as may have survived the first engagements.

Thus the classification used in the paper, which eliminates unarmored vessels and then divides armored vessels into standard and inferior armored vessels, according to fitness to figure in the first series of engagements or only in the subsequent series, this classification which in the discussion is spoken of as "faulty," is the one made by essential strategy, the only rational classification possible which can give an idea of what forces can be thrown into the successive engagements or what the actual naval strength of a nation is.

The classification being made, the next step in the determination of naval strength consists in the estimation of the power or force which the nation in question possesses in each of the three divisions, using these three kinds of power in making all comparisons and drawing all conclusions. In making such an estimate, the only plausible basis is that of tonnage, affected by a coefficient or factor of efficiency, furnishing the two factors quantity and quality. Any descriptive method whatsoever will be found laborious, lacking in comprehensiveness of application, and altogether inadequate. All the features of a vessel may be classified as elements of offense or elements of defense. Any one or any number of one or the other or both of these kinds of elements taken as a basis will be found utterly inadmissible on the slightest examination. The features of vessels classed together are too varied to admit of any descriptive method whatsoever. The varying features cited in the discussion criticising the method of using tonnage show that the method of tonnage is the only plausible method. Since it was necessary to estimate the naval strengths, it may be interesting to know what other method may have been in the mind or could have been suggested by the author of the discussion in question.

The tonnage furnishing directly the factor of quantity, it remains to determine the factors of quality. There are two methods, which may be called the exact method and the approximate method. The exact method consists in the following parts: (1) The determination of the elements of offense and the elements of defense and the relative weight or value of each element and the nature of its relation to the whole. (2) The establishment of a standard in each division of the classification for each of the elements of offense and defense. (3) The determination for each vessel of sub-partial coefficients representing the degree or value of its various elements of offense and of its various elements of defense as compared with the standard elements. (4) To derive partial coefficients, one a coefficient of offense, and the other a coefficient of defense, by treating the sub-partial coefficients of offense and those of defense found in (3) by the values or weights found in (1) in accordance with their relation to the whole. (5) To derive the *coefficient of reduction* for the vessel by taking the simple product of the two partial coefficients, the coefficient of offense and the coefficient of defense. This coefficient of reduction will represent the *quality*;

the *equivalent tonnage*, the quantity sought, will be the product of the actual tonnage by the coefficient of reduction. The sum of the equivalent tonnage for all the vessels of the nation in the division will represent the naval strength of the nation in that division. The divisions of the classification represent adaptability for the various kinds of engagements, and the results arrived at furnish all the elements needed for a comparison.

Moreover, a coefficient of reduction can be established for passing from one division to another, and the strength of the entire navy can be expressed in a single quantity in any of the divisions, expressing the nation's entire force available for any kind of engagements, engagements against unarmored tonnage, against inferior armored tonnage, or against standard armored tonnage. It could further be used to transfer one or more vessels from one division to the other, and would show the result or advantage of detailing it or them to perform one or the other duty. It would give an insight into the advantage of different combinations of vessels in a fleet, of the value under various conditions of a fleet of heterogeneous vessels, of the advisability of having any vessel or number of vessels detached or withdrawn in any engagement or during any portion of an engagement. Further applications need not be pointed out; they will be contained in a subsequent paper devoted to the exact or absolute method outlined.

In the approximate method the analysis of the features of the vessels is avoided by assuming that these features, reflecting the condition of progress of the time when they were produced, will have their general quality defined by this condition, and the method consists in finding the mean date of the tonnage of each division. In comparisons this method requires that cognizance should be taken of the relative degree of progress in each country at the time of the mean date, and of the degree of improvement which the interval between dates at the time would indicate. To make the results more accurate, general cognizance can be taken of the prominent features of design or construction influencing quality, which differ in the countries compared. For the purposes of the paper, it was sufficiently accurate to eliminate unarmored tonnage as not influencing primarily the result of the engagements for control of the sea, and to draw the line between standard and unarmored tonnage by judgment between the vessels considered fit and unfit to enter the first series of engagements. In placing this line, the vessels on both sides were analyzed summarily as to their elements of offense and defense and the decision made accordingly. Though to indicate in a few words the general character of the limiting vessels, reference was made to their date, it was not this date that determined the decision. It is not *age*, as erroneously concluded in the discussion, but *fitness* that determines whether by this method a vessel should be entered on one side or on the other of the dividing line. An armored cruiser just launched cannot enter the class of standard armored tonnage, though a battleship launched ten years ago can. *Age* is used in arriving at rough

conclusions as to quality, but has no influence, except in so far as it influences fitness, in determining the class or division to which a vessel is assigned. In the first method, the principle of which is precisely the same, no use whatever is made of age.

It should be pointed out that in this approximate method the age of a vessel does virtually act as a coefficient of reduction, and that in fact every ton of every ship does not receive equal weight, as supposed in the discussion, for the age of each vessel, assumed to be an index of its quality, has its due proportional influence in determining the age of the whole, which is taken as the index of the quality of the whole.

As to the choice of the date to be assigned as the date of birth of a vessel from which to reckon her age, it should be borne in mind that the object sought is quality, and that the age should transport the mind to the date whose degree of progress is reflected or embodied in the vessel. Though the design of a vessel may not be changed during the course of her construction, though weights and dimensions may remain unaltered, the quality of the material, a quality ranking next to design in importance, changes during practically the whole course of construction. This is particularly important in the case of armor. Radical changes may have taken place in the quality of armor turned out when the vessel is laid down and the quality turned out when the armor is put on.

In consequence, of the three dates in the growth of a vessel, the date of laying down, the date of launch, and the date of completion, the middle date, the one employed in the paper, and not the first date, as advanced in the discussion, is the date whose degree of progress is more nearly embodied in the vessel, and which in consequence should be selected as the index of quality.

In the case of the two fleets, British and French, it should be pointed out that in England few changes, if any, are made in design, even in details, during the course of construction, which is rapid, while in France changes of a serious character are constantly made, such, for instance, as the moving of the torpedo tubes from above to positions below the water line, or even in the distribution of armor, modifications of the splinter deck, changes that have been recently made in consequence of the development of the rapid-fire gun and the use of high explosives for bursting charges, and the use of steel shell containing large charges of powder. Thus in France, where the construction is long, due in part to the changes referred to, changes which add to quality, an advantage which has been accepted to counterbalance in part the disadvantage of delay, the real date of a vessel is much farther from the date of laying down than in England; and, further, for the same reason, [illegible]se the date of launch for determining the age of a vessel in both cas[illegible] is a discrimination to the disadvantage of France instead of a discrimination to the disadvantage of Great Britain, as advanced in the discussion.

It should be pointed out, also, that in the case of the British vessels of large tonnage it will be found on examination by a rough application of the exact method that the powers of offense and of defense are

not as commensurate with their tonnage as they are in the case with contemporary French vessels. A greater quantity of coal adds but little to increase military superiority when the enemy has all the coal needed. It will be found on analysis that the battleships of the Royal Sovereign class outmatch very little for offense and defense the contemporary French battleships of more than two thousand tons less displacement, and, in consequence, the simple addition of tonnage is a discrimination to the disadvantage of France instead of the disadvantage of Great Britain, as advanced in the discussion.

It is not the author's intention to raise the question of the comparative value or worth of French and English construction, but the question of discrimination being up, he considers that in addition to the discriminations pointed out as disadvantageous to France, there is another of not less importance in the assumption that design in the two countries has been on an equality of advancement or progress. Not to mention such points as the perfection and adoption of water tubulous boilers, many years old in France but comparatively new in England, it will suffice to point out simply the lapse of several years that has intervened between the time of appreciation in the designs of the two countries of the necessity of the distribution of armor with a view to protection against projectiles carrying high explosives, and semi-armor-piercing shell with heavy powder charges, differences as indicated in France in the increase of area covered by light side armor, in the protection of medium caliber guns and the development of the splinter deck.

Thus, in sum, the method and classification employed in the paper for the estimation of naval strength, criticised in the discussion, are founded on and flow out of essential innate strategy. Though all of the intermediate elements that must necessarily be incident to an estimation of such a nature as that of naval strength are free and open to individual opinion or judgment, though the parts and details may vary, the author believes the method to be final, and combined with a separate consideration of natural strategy and mental estimate of human strategy, to be comprehensive and unassailable.

In the case of the approximate method, used for the purposes of the paper, the result instead of discriminating against Great Britain, as advanced in the discussion, discriminates incidentally against France.

For the comparison of the future naval forces, it will suffice to mention that the new vessels causing the changes are all enumerated, and that the dates set for their completion were derived a year ago in each case by conservative estimates based on the stages of advancement and taking due account of the time required for building in the different countries. If these times have changed or do change, they will modify only to that extent the result.

It should be borne in mind that in England, where of recent years rapidity of construction has taken the form of strong rivalry between the different yards, the terms date of laying down, date of completion do not mean what they do in France. For instance, in England at

the date of laying down material, progress has been made in the preparation of material, which would correspond to a date some time later in France. In the case of the Magnificent and Majestic, put down as expecting to be completed before the Renown, in July, 1896, if these vessels are actually to be ready for commission at that date, a prodigy will have been performed even for England's remarkable rapidity of construction, and no adequate cause can be assigned other than an intense desire of the authorities to remedy to the utmost the inevitable condition pointed out in the paper.

Referring to the accuracy of numerical statements in the paper, occasion should be taken, in view of the equivocal use of the word "exaggeration" in a subsequent discussion, to mention at this point that they are from sources of the utmost reliability. The figures for strength of armies are from the Bureau of Information of the War Department, corrected by the Bureau up to the date of completion of the paper. The figures for naval expenditures and appropriations are from official returns in the budgets of the different countries. Those for populations and rates of increase are from statistical returns made in 1894. Those for vessels, tonnage, date of launch, material of hull, kind of guns, etc., do not admit question. The only possibility for variation from the statements lies, as pointed out, in the estimation of dates of completion of vessels now building, dates liable to be changed, and even here modifications can be but slight, and, where found, will be the results of abnormal conditions which cannot enter estimates.

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History presents two forms of sociological wave. In one form, a race or nation or a religious sect has advanced across territory not its own in one or more pronounced directions. Such has been the case of the invasion of Europe by the Huns, the Saracens, the Mongols, and the Turks. In the other, a race or nation has expanded circumferentially like a wave of disturbance, as in the case of the Celts, Romans, and the Teutons in Europe and the Mongols in Asia. The former form of wave, which may be termed the *wave of translation*, has had its sources in sociological impulses beyond Europe. The waves have advanced across long distances in comparatively short times, receiving but slight reinforcements and expending their force till checked by sociological barriers, when they began to recede. The invaders have been of different race origin and have remained alienated from the native peoples, and recession, though slow, has been steady and sure.

The second form of wave, which may be termed the *wave of radial expansion*, has had its historic origin in each case in Europe itself. The sociological forces have been long and cumulative in their processes, the waves gathering new force as they advanced along radii or, as in the case of Rome, around the whole circumference. The races have all been of Aryan origin and have spread over Aryan expanses. They have been mixed with the native peoples, have assimilated them, have been assimilated by them, and their influence has been profound and

perpetual, exception being made of Rome in her outer circles, which reached far into the regions of the lower races.

It is to the second form of wave that the Slavic wave belongs. Starting from a nucleus in the central part of what is now European Russia, with an area of about 800,000 sq. miles, after the overthrow of the Tartars four centuries ago, it has extended radially in all directions by steady, unremitting strides, till it now compasses more than 8,500,000 sq. miles, about ⅙ of the entire land surface of the globe. This unprecedented expansion belittles Rome when she spread by successive steps in about the same length of time over Italy, then Carthage, Greece, and Macedonia, then Spain and Cisalpine Gaul, then Syria, Parthia, Egypt, and Transalpine Gaul. It overshadows the remarkable phenomenon of the Teutons setting forth from the German forests, tribe after tribe, Goths, Franks, Burgundians, Vandals, Angles, Saxons, Jutes, over one Roman province, then another, into Italy, over one part of Gaul, then another, into Spain, over to Africa, and across to Britain. The Romans assimilated the tribes of Italy, and later mixed with the inhabitants of Gaul and Spain, and everywhere exerted a profound influence; but in their outer dominions their rule was only military, the rulers remaining foreign to the ruled; the fatal characteristic of the wave of translation, foredestined to overthrow.

The Teutons went forth as separate tribes, and mixed with but did not assimilate the native tribes overrun. Their influence was everywhere profound, an exception being made of the Vandals; but it gave rise to new composite nations, the invaders gradually losing themselves in the new nations.

The Slavic expansion has been characterized by universal assimilation. Whether Slavic influence pre-existed or not, the moment the Russian frontier has swept around a section or country, an irresistible system of Russifying has set in. It is as though the Romans had assimilated the populations beyond Italy as well as those within Italy; as though the Teutons had been united instead of appearing in different tribes, and had assimilated as they advanced. The Slavic wave, advancing with an unbroken front, without any tendency to internal division, absorbing into itself new populations, grows stronger and more irresistible instead of dividing, weakening, or diluting its force, as did the Roman and Teutonic waves. Vast, wild expanses, that would have frightened back or swamped a less rugged race, have been leaped till already the northern and eastern boundaries are oceans of two continents. Sociological barriers have been as naught. An ostrich-like digestion has assimilated foreign sociological morsels hitherto utterly indigestible. No wave in history has had the proportions of the Slavic wave, and none offers even the suggestion of a parallel of the combination of elements that make up invincibility, irresistibility. Attention may be called at this point to the fact that no radius has been excepted in the advance along the whole circumference.

Referring to the discussion that advances the idea of specific, not general, expansion, it will suffice to point out that, taking a map and

turning back only a few pages in history, starting in Finland at the Swedish boundary, continuing down through Europe, over to Asia, and across the sea to Corea, it will be found that every foot of Russia's endless frontier is under heavy tension, is pressing heavily outward. It may be added, also, that the simple reference made to Turkey, India, and Corea, in connection with the idea of specific expansion, is sufficient to show that the expansion is general.

Of the remarkable features of this wonderful sociological phenomenon, the most striking is the manner in which the Non-Aryan or Turanian races, as well as the Aryan races, one and all, are being assimilated. Though other and higher Aryan races may bear sway in Asia, no one gives promise of being able to assimilate the Asiatics. The rugged Slavic race alone gives promise of being equal to this giant's task of Aryanizing Asia.

Though the process of Russianizing or Slavonicizing elevates the lower races, and would infuse a wonderful new life into the stagnant blood of Asia, it drags down mercilessly the higher races; it would throw Europe back almost to the days of serfdom, with long, agonizing, but relentless pangs. The Russianization of Poland is a case of the process of this assimilation, though with the other nations, not having the preparations of similarity, of proclivities and temperament, the process would be far more severe. Though the sword, referred to in the discussion, would characterize only the first conquest and the suppression of subsequent rebellions, the ordeal involved in the extinction of native tongue, the destruction of individual liberty, of individuality itself, would be far more severe than "fire and sword." To show that, viewed from the westward, a dense darkness hovers over the Slavic wave, it need only be recalled that the mass of the Russian nation, the mass that makes up the wave and gives it the characteristics pointed out above, was only emancipated from serfdom in our own generation, and on the ladder of civilization in its great objective feature, higher standard of comfort and amelioration of the condition of individual life, stands on a round far down, centuries below the round occupied by western Europe.

Russia's representatives abroad, all of whom come from among the aristocracy, a class largely of Teutonic race origin, having had centuries of cosmopolitan association with western Europe, one of the most intelligent, highly educated classes in the world, produce false impressions as to the Russian race. Though they formulate the nation's ambitions, though they wield the great masses with unsurpassed sagacity, having the power to tax to any limit the resources offered by the countless number of stalwart men, seizing on all the improvements in weapons and in methods that western science devises, though peerless in diplomacy, though contributing the guidance of a high intelligence, and though to the greatest advantage wielding the great race with the incalculable power given by absolute obedience, innate courage, and unlimited powers of rugged endurance, they nevertheless form but one and one-half per cent. of the population. The process of as-

similation, of transformation, wherever found, has always and must always come from the masses who stand immeasurably below.

Russian ambition, though true to the universality of its possibilities and neglecting no opportunity in Asia, is centered hard on Europe, where it takes the immediate definite form of seeking a southern waterway to the westward, having already a northern one, and gaining at the same time the gateway to the three converging continents. The strategic importance of the Balkans, recognized all down the centuries, cannot be overestimated. Its possession by a strong nation would have a profound, far-reaching effect on the Russian question, as pointed out in the discussion; but, on the other hand, its possession by Russia would be a death-knell to western Europe. Of such vital importance is this Balkan question that it may be assumed that Russia will not be allowed by the nations awakened to antagonism to occupy it without war, while it may be assumed with equal certainty that Russia will not peaceably allow it to be occupied by another strong nation. A strong Balkan nation can arise only by a new birth. It is out of the question that Austro-Hungaria, the only nation available, finding great and growing difficulty in containing the heterogeneous elements in its present borders, and having no expanding population, will attempt to occupy or could effectually occupy the peninsula.

What are the chances of the birth of a new nation? What are those signs in Southeastern Europe which in the discussion are taken to be signs of pregnancy?

The most marked sociological and political feature of contemporary history, referred to in the paper, is the tendency to consolidation in peoples of the same race and the tendency to separation in peoples of different race, though under the same government.

The total population of the Balkan peninsula, including the Hungarian provinces of Bosnia and Herzegovina, is about 20,000,000, exclusive of the Turks, who number about 1,700,000, whose occupancy is not permanent. Of this population about 5,000,000 are Roumanians of mixed origin, about 3,300,000 are Bulgarians or Bulgars of Turanian origin, with Slavic admixture; about 2,000,000 are pure Slaves, and the remainder, 10,000,000, are made up of Greeks, Albanians, Armenians, Magyars, Circassians, Jews, and Gypsies. This heterogeneous population has shown no tendency to unite. The "signs" have been those of consolidation of the races emerging from the Turkish yoke, and of formation into separate small states or principalities. Growing antagonism and rivalry, not tendency to union, have been the characteristics of these small states in their relations with each other. Even the power of self-government is questionable, so deep have been the effects of the centuries of subjugation to the Turk. Of these contiguous races, no one has shown yet any particular capacity for assimilation. The Magyars of Hungary have shown themselves equally incapable. Though the influence of the western powers might effect a Balkan Confederation in the face of Russia, or Russia and France (the power to do which in the

latter case will not be here discussed), yet all the indications point to the continued separation of the races. As far as can be seen now, these races will not flow together until they are all absorbed in their great assimilating neighbor. This destiny seems set apart by fate for all the small heterogeneous races found in Bohemia, Hungary, and Southeastern Europe, which are fast ripening under Russian influence, and for the rest of the races of Europe also, unless some unseen unifying process comes from below the horizon.

Occasion should be taken to point out here that sociological processes, particularly those embodying increase of population and assimilation, are slow, like all great, irresistible forces. It is, in consequence, beyond human knowledge to fix times for the accomplishment of the great phenomena foreshadowed above. It may be added that it is a superficial reading that classes the paper in the category of date-fixing prophecies. More careful reading will show that the paper is an analysis of situations, certain, probable and possible, only in so far as they permit analysis, and that it attempts in no manner to determine the other indeterminable elements that enter to decide the times of the war.

As to the peninsula at the other end of Europe, that appeals so strongly to the strategist's eye, whose possession as the home of a great and powerful race would profoundly influence the destiny of Europe, it needs only to be called to mind that all indications point to continued decline in Spain, internal division, increased indebtedness and loss of credit, rebellion in colonies. Rejuvenation has not occurred in the history of Latin races grown rigid with age, and there is no nation in Europe, excepting the one in the East, that could spare population to infuse new blood into the Spaniard's veins. It may be added, further, that it could not be assumed that a new Spain would be with the passive powers. The immediate advantages of spectatorship or alliance with France and Russia would be even greater than those pointed out for Italy. Unless Spain, which is farthest from Russia, could be taught to see across immediate interests to see the final vision, it would be a dangerous experiment, if it were possible to make it, to put great power into her hands.

The picture of a great Iberian power, more even than the picture of a great and growing Balkan power, being allowed to rise from infancy to block the path of Giant Russia, a picture outlined from broad mental sweep and strategic grasp, is but a vision that vanishes under a steady gaze.

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The conclusions arrived at are, in sum, as follows:

1. The rise of Japan exerts a stabilizing influence on Europe in restoring equilibrium on the sea, and this equilibrium promises to continue till Italy decides on her future policy, when the treaty of the Triple Alliance expires. It further raises a serious obstacle to Russian advance in the East, and will draw away from Europe a larger share

of Russian strength, diverting more of Russia's attention to Asia, where lies her great mission. The events of the war in the East, particularly those connected with its conclusion, have drawn the gaze of the world to Russia, from which fruitful results will flow. These events have emphasized, in addition, two facts that should be signalized, namely, first, the solidity of Russia's alliance with France, a fact emphasized by every event of the past few years, an alliance which, as pointed out in the paper, can be dissolved only by disastrous war, threatened or inflicted, or by the game of waiting, a game advantageous to Russia, which might overtax French patience, or, if possible, might cause a change of sentiment in France; second, the ascendancy of Russian diplomacy, the consummate ability of its diplomats, and the tremendous vantage-ground that it holds while Western Europe is divided.

2. The naval estimates, questioned in the discussion, are based for method and classification on essential strategy, and in results are accurate within the degree of approximation suited to the present treatment, admitting of variations as pointed out, which are discriminations against France in the estimates of vessels completed, and from appearances against England in the estimates for the future in the slight deviation from the normal length of time that may be consumed in the completion of vessels under construction.

3. The situation in Europe, viewed in the light of history, presents the most remarkable phenomenon of sociological wave that the world has seen, a wave which, though still in its youth, has reached proportions hitherto unknown. Belonging to the irresistible class of radial expansion, this wave embodies all the elements of irresistibility found in previous examples, without any of the elements of weakness. Physical and sociological obstacles hitherto insurmountable vanish as nought. This wonderful phenomenon offers the grand prospect of Aryanizing Asia; but, on the other hand, it is a terrible menace to Europe, which would be thrown down centuries of progress; while the situation in Europe, before this menace, is nothing short of desperate.

The absorption of Southeastern and large additional portions of Central Europe appears inevitable. Whether Western Europe is to follow will depend on the capacity of the western nations for union.

The test of history is to be applied to our high western civilization, whether, with its ameliorated condition and higher life of the individual, it has lost, like the high civilizations of the past, the hardihood and elements of combination or association, which alone can guarantee existence in the face of a lower but more rugged race which uses all the weapons and all the methods of the higher race, while possessing greater endurance, if not greater courage, where the individual is lost in the unity of the whole.

PROFESSIONAL NOTES.

THE BRITISH NAVAL MANŒUVRES FOR 1894.

[ENGINEERING.]

The official account of the partial mobilization and naval manœuvres of last year has just been issued. It is a brief document, dealing in a summary method with the operations of the two fleets. It appears that 96 vessels of all classes were engaged, 24 of these being torpedo-boats and 26 small special service vessels. There were 33 cruisers, 12 battleships and one coast-defense vessel. The total was larger than any during the past five years. The total tonnage was 305,362, the number of officers and men employed being 20,853 of the Royal Navy; in addition to which there were 535 men of the Royal Naval Reserve mobilized. The whole number of ships were divided, as usual, into two bodies, designated the Red and Blue fleets.

It is unnecessary to follow the bare description given of the details of operations. The operations took place mostly off the coast of Ireland. There was a forbidden belt. There was the usual amount of scouting, cruising and manœuvring, and on August 5 the combined Blue Fleet, composed of 22 ships, were sighted on the port bow of the B Red Fleet, consisting of 15 ships. The Blues manœuvred to prevent the Reds from getting into Belfast, and an engagement which lasted about 50 minutes took place. The Red ships got into Belfast Lough, but in doing so they passed within six cables of the Maidens, and thus broke one of the rules, the penalty being that they were put out of action by the umpire for 24 hours. After this the Blue Fleet stood to the southward to look for the remainder of the Red Fleet, which was discovered. An engagement began, and the part of the Red Fleet which had been ruled out of action followed and took part in the fight. As, however, the Red ships out of action should not have been present, the victory was therefore given to the Blues, who were outnumbered to the required extent. This must have been an unpleasant surprise to the Admiral of the conquered fleet, who was not aware that his auxiliaries were officially nonexistent, although very palpably present in actual force.

No ship was put out of action by a torpedo-boat, a fact to be chiefly attributed to the lightness of the nights. One of the Red torpedo-boats, however, had apparently a chance which she failed to take advantage of, supposing her enemy to be one of the group exempted from torpedo attack by the rules. This incident, as well as that of the Red ships being out of action, and yet able to take part in the fight, shows the difficulty of bringing make-believe warfare to the likeness of the real thing.

The Red torpedo-boat referred to, which failed to attack her opponent through a misconception of her character, had been driven off by a

"catcher"—we thought the term was tabooed in naval circles—and at first missed the Blue Fleet, but managed to keep up with it and got within range of the rear ship, which, as stated, she did not attack. The lieutenant in command states that, owing to the speed of the hostile fleet, the boats were unable to regain their position for attack when once it had been lost. "From this it seems permissible to infer," says the report, "that high speed will be of itself no unimportant protection to ships traversing at night narrow waters infested by torpedo-boats"; a proposition which we should have thought a self-evident fact.

The torpedo-boat operations are described as having been upon a too restricted scale to supply much valuable instruction, a remark which applies equally as well to the report itself. So far as the operations went, however, they tend to confirm the view that the most effective employment of the torpedo-boat in war will be limited to sending her to attack an enemy's ship in a known position within the boat's range of action. The necessity of combining with torpedo-boats vessels of a larger class to discover the enemy is also insisted upon. A mere flotilla of torpedo-boats is therefore considered "as a belligerent factor of distinctly imperfect efficiency." It is surprising how much attention the torpedo-boats always seem to occupy in these manœuvres, and yet we are always being told they are little or no good.

TEST OF THE PNEUMATIC GUNS.

[American Engineer and Railroad Journal.]

In our issue for September, 1894, we illustrated and described the pneumatic dynamite guns that have been placed at Sandy Hook for the protection of the channels entering New York harbor. Our readers will remember that this battery consists of one 8-in. and two 15-in. guns, built by the Pneumatic Torpedo and Construction Company. For the details of the arrangement and construction of the battery we refer to our previous article.

As the guns were built under a contract with the government, wherein the latter assumed no responsibility except to pay for the guns, provided they fulfilled the requirements of the agreement, it was of the utmost importance that the performance of the guns should be such that the most exacting board could find nothing to criticise. The testing of these guns had been carried on for some time under the auspices of the company's officers, and an elaborate system of records preserved showing the fall in pressure in the air cylinders for various air and service charges, the former corresponding to blank cartridges in the ordinary rifle. After a long series of such trials, in which the setting of the valve was carefully observed for ranges and action, the official acceptance test was made.

The endurance test of the whole plant was, as given in our previous account, 50 rounds in the first hour, 20 being from the 8-in. gun and 15 from each of the two 15-in.; then, for the next two hours, 30 rounds per hour. These were merely "air shots," but the valve was set for extreme range. The results of this excessive trial, that far exceeded anything the battery could ever be called upon to meet in service, were

that 50 shots were fired in the first hour, 33 in the second and 36 in the third. The initial air pressure at the firing of the first shot was 1008 lbs. per square inch, and though this was not exceeded at any time during the trial, it was touched at several times during the second and third hours. The lowest point touched by the pressure was 930 lbs., at which the sixth shot in the third hour was fired. It may be roughly stated that a firing pressure of 1000 lbs. was maintained throughout, and no shot, with the single exception of the one mentioned, was fired at less than 990 lbs.

We have mentioned this endurance test first because it depended upon the machinery of the steam plant for its execution, although it was the last on the list.

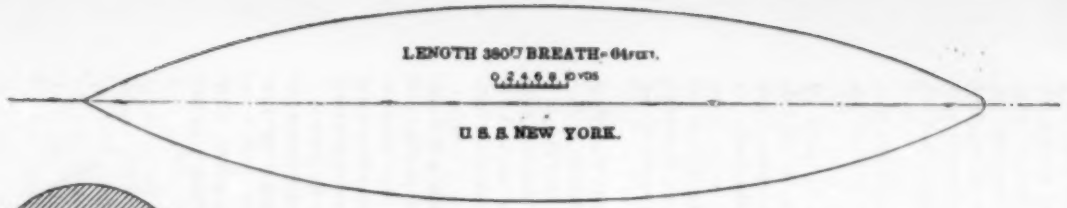
The development of the pneumatic gun—for it has been a case of development—started with the fundamental idea of throwing a charge of dynamite with compressed air; and it having been demonstrated that this could be done, it became necessary to so control the admission of the air that the shot could be fired accurately, for it would be of little use in hurling dynamite about unless there is some probability of its striking the object at which it is aimed, and at this point the development of the gun came in as exemplified by the wonderful valve designed by Captain Rapieff.

It is useless to deny that the original guns were inaccurate, but this does not hold good of the present battery at Sandy Hook. Through the courtesy of the company we are enabled to give diagrams of the targets of three sets of these shots. The striking point of the shots was located by means of plane tables. For the shorter ranges there were two observers stationed on either side of the battery, at distances of 596 yds. to the right and 627 yds. to the left; while, for the longer ranges, there was a third observer on the Romer Shoals beacon, which stood off from the line of firing at an angle of 17° 19′ and a distance of 5150 yds.

It would be uninteresting to our readers to recapitulate the results obtained by each shot, and we therefore confine ourselves to the sets that are here plotted. In Fig. 4 it will be observed that there is a plotting of the zones of danger to a first-class armored vessel due to the explosion of 500 lbs., 200 lbs. and 100 lbs. of high explosive respectively, as plotted from the formula of General Abbot. The plotting of the three sets of shots is done on this same scale.

Referring to Fig. 1, which represents the plotting of five shots fired from the 15-in. gun with 500 lbs. of explosive in each shot. The specification required that 74 per cent. of these shots should fall within the area of a rectangle 120 yds. long and 30 yds. wide. As a matter of fact, the whole five fell within a rectangle 41 yds. long and 10 yds. wide, while four out of the five fell on the line of fire. Fig. 2 is the similar plotting, eight shots containing 200 lbs. of explosive that fell within a rectangle 42 yds. long and 5 yds. wide, whereas the specifications only required that 54½ per cent. should fall within a rectangle 120 yds. long and 30 yds. wide. This Fig. 2 represents the extreme contract range, and the figures appended to the striking point of each shot indicate the distance from the battery at which it struck the water. Fig. 3 is a similar plotting of shots containing 100 lbs. of explosive fired from the 8-in. gun, and shows that the five shots fell within a rectangle of 57 yds. long and 3¾ yds. wide,* while the specification target was 120 yds. long and 30

*In the drawing, the distance of shot No. 1 should be 2578 yds. instead of 2518 yds. as marked. The scale of the plotting is correct.



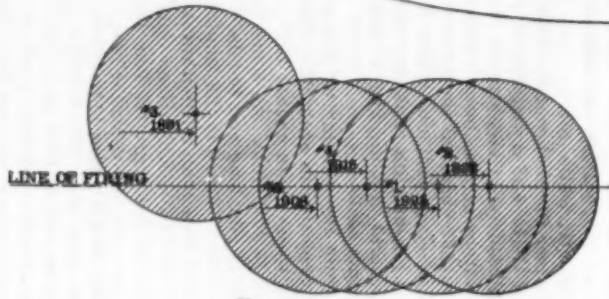


FIG. 1.

Plotting of Shots from 15-in. Gun with Full Caliber Projectiles and 500 lbs. of Explosive.

FIG. 2.

Plotting of Shots from 15-in. Gun with 10-in. Sub-Caliber Projectiles and 200 lbs. of Explosive.

PLOTTING OF SHOTS FROM PNEUMATIC DYNAMITE GUNS AT SANDY HOOK, N. J.

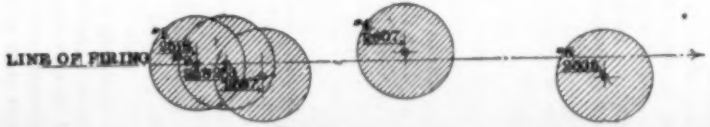


FIG. 3.

Plotting of Shots from 8-in. Pneumatic Dynamite Gun with 100 lbs. of Explosive.

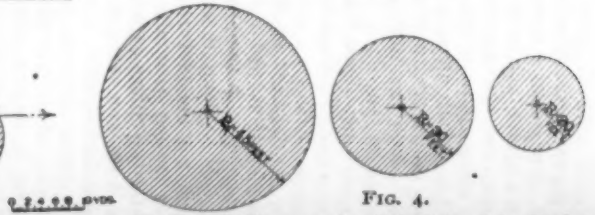


FIG. 4.

15-in. Full Caliber Projectile with 500 lbs. of High Explosive.

10-in. Sub-Caliber Projectile with 200 lbs. of High Explosive.

8-in. Projectile with 100 lbs. of High Explosive.

ZONES OF DANGER TO FIRST-CLASS ARMORED

yds. wide, with 66 per cent. hits required. We may therefore safely conclude that the accuracy of fire of these guns stands at a high point.

In our September issue we stated that these guns "command the whole southern approach to New York harbor." An actual plotting of the ranges shows that the 15-in. guns can throw 200-lb. charges to any point along the main channel for a distance of about 9000 yds., and for 4200 yds. through the swash channel. If a vessel were to enter the harbor at a speed of 20 miles per hour, it would, therefore, be exposed to the fire of the 15-in. guns with 200-lb. charges for 16 minutes if it were running the main channel and 7½ minutes if it were in the swash channel. In the first case the two guns could throw 20 projectiles, and in the latter 10 projectiles. Further, the guns are capable of throwing 500-lb. projectiles to any point for a distance of 4300 yds. along the main channel, and could fire eight projectiles at a vessel running 20 miles an hour before it was out of range, but could not reach the swash channel. This rate of firing cannot even be approached by the rifled guns, while there is nothing in the shape of a torpedo-thrower that can possibly be compared with this performance.

The acceptance tests also included an examination into the time required for the mechanical operation of the guns, such as elevating, depressing, and traversing. The guns can be operated by hand or by electric motors. The latter will carry them through 360° in 48⅞ seconds for the 15-in. guns, and 1 minute 25½ seconds for the 8-in. guns, while the same work can be done by hand in 8 minutes 11 seconds and 5 minutes 56 seconds respectively. The electric motor will elevate the 8-in. gun from 0° to 35° in 14 seconds and depress it in 15 seconds; the elevation and depression of the 15-in. gun to 34½° in 8⅛ seconds and 9⅛ seconds; hand power requiring 45 seconds and 48 seconds for the 8-in. and 26⅝ seconds and 26 seconds respectively.

One of the prime elements in the success of a dynamite gun is to have a suitable fuze. In regard to this we can only say at this time that out of all the shots fired—and there were 38 official and 8 extra for the company's exhibition—only two failed to explode on impact, and some were fired at the close range of 100 yds. In a future issue we will illustrate this fuze and then give a further account of its action in these tests.

The trials demonstrated that this battery has exceeded the demands of the specifications in almost every particular, and it has therefore been accepted by the government. The company are now at work upon the battery that is to be located in the harbor of San Francisco, thus giving to the main Atlantic and Pacific harbors of the United States the most efficient type of torpedo-throwing battery.

LEGAL ELECTRICAL UNITS IN THE UNITED STATES.

The units of electrical measure recommended by the International Electrical Congress, held at Chicago in 1893, were officially adopted by the U. S. Office of Standard Weights and Measures, with the approval of the Secretary of the Treasury. While this action affected all government contracts in which electrical measures were involved, it was in no way binding upon state, municipal or private operations. To remedy this deficiency, the law given below was passed by both houses of

Congress and signed by the President, and became a law on July 12, 1894. It supersedes all previous action in the matter, and substantially agrees with the recommendations of the International Congress. The specifications referred to in Section 2 have not yet been prepared by the National Academy of Sciences, but are expected shortly:

AN ACT TO DEFINE AND ESTABLISH THE UNITS OF ELECTRICAL MEASURE.

From and after the passage of this act the legal units of electric measure in the United States shall be as follows: (1) The unit of resistance shall be what is known as the international ohm, which is substantially equal to 1,000,000,000 units of resistance of the centimeter-gram-second system of electro-magnetic units, and is represented by the resistance offered to an unvarying electric current by a column of mercury at the temperature of melting ice, 14.4521 grams in mass, of a constant cross-sectional area, and of the length of 106.3 cm.

(2) The unit of current shall be what is known as the international ampere, which is one-tenth of the unit of current of the centimeter-gram-second system of electro-magnetic units, and is the practical equivalent of the unvarying current, which, when passed through a solution of nitrate of silver in water in accordance with standard specifications, deposits silver at the rate of 0.001118 gram per second.

(3) The unit of electromotive force shall be what is known as the international volt, which is the electromotive force that, steadily applied to a conductor whose resistance is one international ohm, will produce a current of an international ampere, and is practically equivalent to $\frac{1000}{1434}$ of the electromotive force between the poles or electrodes of the voltaic cell known as Clark's cell, at a temperature of 15° C., and prepared in the manner described in the standard specifications.

(4) The unit of quantity shall be what is known as the international coulomb, which is the quantity of electricity transferred by a current of one international ampere in one second.

(5) The unit of capacity shall be what is known as the international farad, which is the capacity of a condenser charged to a potential of one international volt by one international coulomb of electricity.

(6) The unit of work shall be the joule, which is equal to ten million units of work in the centimeter-gram-second system, and which is practically equivalent to the energy expended in one second by an international ampere in an international ohm.

(7) The unit of power shall be the watt, which is equal to ten million units of power in the centimeter-gram-second system, and which is practically equivalent to the work done at the rate of one joule per second.

(8) The unit of induction shall be the henry, which is the induction in a circuit when the electromotive force induced in this circuit is one international volt while the inducing current varies at the rate of one ampere per second.

Sec. 2. That it shall be the duty of the National Academy of Sciences to prescribe and publish, as soon as possible after the passage of this act, such specifications of details as shall be necessary for the practical application of the definitions of the ampere and volt hereinbefore given, and such specifications shall be the standard specifications herein mentioned.

SHIPS OF WAR.*

[ENGLAND.]

THE MAGNIFICENT AND MAJESTIC.

The following comparative table gives the main features of the new battle-ships, compared with those of the Anson, the Royal Sovereign, and the French vessel Charlemagne now being built:

PARTICULARS.	MAJESTIC.	ROYAL SOVEREIGN	ANSON.	CHARLEMAGNE.
Length, feet	390	380	330	385
Beam, feet	75	75	68½	66 ft. 7 in.
Draught, feet	27½	27½	28	25 ft. 10 in.
Displacement, tons	15,000	14,260	10,650	11,232
Freeboard, feet	21½	19½	10½	25 ft.
Indicated horse-power	12,000	13,000	11,000	14,000
Speed, knots	17.5	17 5	16.8	18
Coals, tons { at designed load	900	900	900	680
Coals, tons { total capacity	1850	1400	—	1100
Armament* { Main	4 50-ton guns	4 67-ton guns	4 67-ton guns	4 11¾-in. guns
	12 6-in. Q. F.	10 6-in. Q. F.	6 6-in. B. L.	10 5½-in. Q. F.
Armament* { Auxiliary	16 12-pounder Q. F.	16 6-pounder Q. F.	12 6-pounder Q. F.	6 4-in. Q. F.
	12 3-pounder Q. F.	12 3-pounder Q. F.	10 2-pounder Q. F.	36 smaller Q. F.
Total weight of armament and ammunition	1500 tons	1410 tons	1070 tons	Not known
Height of center line of heavy guns above water	27 ft.	23 ft.	19¾ ft.	29 ft.
Length of vertical armor	250 ft. (including citadel)	250 ft.	150 ft.	Entire length of ship
Weight of armor and armored deck	4300 tons	4550 tons	3130 tons	Not known
Weight of projectiles thrown in four minutes on either beam	30,000 lb.	27,000 lb.	20,000 lb.	20,000 lb.
Weight of projectiles thrown in four minutes axially, fore or aft	12,000 lb.	12,800 lb.	8000 lb.	14,600 lb.

* Exclusive of machine guns.

The Magnificent was successfully floated out of dock on December 19 and the Majestic on January 31. These two vessels form part of a fleet of seven of precisely similar character already under construction or laid down. When completed they will be, in point of weight of broadside and end-on fire, as well as in respect of armored protection, the most modern and formidable engines of war as yet seen afloat. For, although the main armament in the barbettes consists of 12-in. 50-ton guns, instead of the huge 70-ton weapons of the Royal Sovereign and Hood, the extra rapidity with which these lighter and more manageable pieces of ordnance can be worked, and the tremendous preponderance of large caliber quick-firers which can be discharged six and seven times per minute, render the weight of metal thrown in a given interval of time far greater in the two vessels now under consideration. Similarly, although the actual thickness of armor-plating upon the sides and barbettes has been lessened, its capacity for resistance has been increased

* Details are from "The Engineer" and "Engineering."

fifty per cent. by Harveyizing it, and the extent of armored surface has been enormously developed. The superficial armored area of the Magnificent's great citadel is, independently of the barbettes, nearly 9000 ft.

The principal dimensions, etc., of the two new battle-ships are as follows: Length, between perpendiculars, 390 ft., or 415 ft. over all; beam, 75 ft. at the water-line; mean draught of water, 27½ ft.; displacement, 14,900 tons; indicated horse power, 12,000; speed, under natural draught, 16½ knots, under moderate forced draught 17½ knots; of coal capacity there is a total storage of 1800 tons, but only 900 tons of this can be carried at the designed draught.

The disposition of the armored protection is quite different from that of the Royal Sovereign class. Instead of a narrow strip of thick armor at the water-line, surmounted by another strip of very thin armor, the upper edge of which is 9½ ft. above the water-line, there is a broad streak of Harveyed steel 15½ ft. wide, stretching from apex to apex of a pointed citadel. This is 9 in. thick upon the broadsides and 14 in. thick around the barbettes, where it merges into bulkheads. Within this armored citadel is the thickest portion of the armored deck, where it is 3 in. on the flat and 4 in. upon the curved sloping edges. Forward and aft, beyond the armored bulkheads, the armored deck is 2½ in. thick at its stoutest part. But an important modification has been made in the armored deck. In all earlier battle-ships the outer edge of this deck is at the summit of the thick armor belt. In the Magnificent and Majestic, however, it curves downwards behind the vertical armor, and the lower edges of the two harmonize, as well as the outer edges of the forward and after armored decks, thus bringing the whole to a uniform level of about 5 ft. or 6 ft. below the water-line. The protective deck is, therefore, of a truly turtle-back character, as first of all developed so prominently in the design of the Vulcan. The barbettes are built upon the citadel ends of the armored deck and are to be plated with 14 in. Harveyed steel. Upon their summits will be revolving armored hoods of sufficient capacity to hold the gun detachments working the guns by manual power, and as the barbettes are pear-shaped in plan, there will be room within the thin ends for the ordinary ammunition hoists and ramming gear required for fixed loading positions. There is, however, an axial ammunition trunk within the barbettes, which descends to the magazines direct, to which we shall advert presently. Another feature for the protection of the water-line is the filling in with water-tight divisions of the angular space between the curved edges of the armored deck and the lower streak of armor belting, thus forming a sort of cofferdam around the vessel at this level. A similar contrivance has been designed for some of the war vessels of France now under construction.

The secondary armament, consisting of 6-in. quick-firers, is all protected by 6-in. armor on the outside of the casemates and 2-in. plates on their other side. A valuable modification has been made in the arrangement of the upper deck battery. Instead of an open space, liable to be swept by the machine and quick-firing guns of the enemy, both from the armored tops and otherwise, this is now enclosed and decked over with a steel shelter deck, the four armored casemates at either corner acting moreover as screens to prevent a raking fire from either quarter. There is also beneath the forward bridge a flying deck, upon which light quick-firing guns will be placed. Above this towers

the chart-room, rising to an altitude of 75 ft. from the under side of the keel. It is impossible to conceive anything more important to the steadiness and discipline of the guns' crews than the fact of their being able to fight their weapons behind adequate shelter, and this question has been thoroughly solved in the upper works of the Magnificent and Majestic.

The armament of these vessels and its disposition is as follows: Two 12-in. wire 50-ton guns are to be mounted upon each barbette, protected by a steel revolving hood, as in the case of the Barfleur and Renown. Beneath the turntables will be a revolving shell chamber, with an ammunition trunk in the center and hoists, so that loading can be carried out with the guns at any position of training. This is independent of the fixed loading positions, whose hoists are in the pear-shaped ends of the barbettes. Thus the rapidity of fire and of the serving of the ammunition are accentuated considerably by this two-fold arrangement, not to speak of the value of an *alternative* system in the event of one having been placed *hors de combat* by accident. It will be observed that whilst the freeboard of the new vessels has been raised to a height of more than 20 ft. forward, the axis of the heavy guns has been also raised to 27 ft. above the water-line, being 4 ft. higher than in the case of the Royal Sovereign class. This will admit of the guns being fired axially forward or aft, without endangering the safety of the deck, an impossibility in the earlier vessels. Upon the main deck are eight 6-in. quick-firers in armored casemates, four on either broadside, and four more of these guns are upon the upper deck battery, one in an armored casemate at each corner, as will be seen in the engraving. The part of the shelter deck above these last-mentioned corner casemates is double plated to give additional strength. In the upper deck battery will be also twelve 12-pounder quick-firers upon shielded mountings, six on either broadside, and the remaining four 12-pounders will be forward and aft upon the superstructure. The two forward ones will be under the flying deck. Twelve 3-pounder quick-firers will be disposed upon the superstructure, tops, and in other situations. Eight machine guns will also be carried, and five torpedo tubes or dischargers. Two 12-in. guns, two 6-in. quick-firers, two 12-pounder, and seven or five 3-pounder quick-firers can be directed simultaneously either ahead or astern, whilst the broadside fired on either beam would be delivered from four 12-in., six 6-in. quick-firers, eight 12-pounder and eight 3-pounder quick-firers. In four minutes a weight of 30,000 lbs. of metal would thus be discharged from one broadside, whilst the corresponding figure forward or aft would be about 12,000 lbs. It must be borne in mind that all this concentration of fire has not been obtained, as in the case of the French battle-ships of the Charlemagne class, by fitting the guns into lateral grooves like the blades of a pocket knife, which must inevitably sacrifice the stability of the ship when axial fire is employed, but that each gun has a clear arc for itself without interfering with any adjacent works or with the rest of the armament.

The propelling machinery of the new vessels consists of two sets of engines of the ordinary inverted triple-expansion compound condensing type, the cylinders being 40 in., 59 in., and 88 in. in diameter respectively, by 51 in. stroke. The twin propellers are of gun-metal, and are 17 ft. in diameter and of 19 ft. 9 in. pitch. The boilers are eight in number, and are of the ordinary marine type, being 16 ft. 1 in. in diameter and

9 ft. 3 in. long, each containing four furnaces. They weigh about 50 tons each. The working pressure will be 150 lbs. per square inch. The main steam pipes will be of steel. The chief novelty in this connection is the application of induced instead of forced draught. The makers of the Magnificent's engines are Messrs. John Penn & Sons; those of the Majestic will be made at Barrow.

The two new battle-ships, although very fine in their lines forward and aft, are tolerably square at the midship section, the result being that their coefficient of fineness below the water-line area is .65 of a solid rectangle contained by the length, beam and draught.

The Magnificent was only laid down upon the 18th of December, 1893, and the Majestic upon the 5th of February, 1894; hence their readiness for floating out in so short a space of time is almost phenomenal.

Ammunition is supplied, save to the 12-pounder gun positions, through passages and trunks which are all either constructed of armor or are under protection. Beneath each gun position is an independent armored trunk, so that accidents from shells bursting between decks would be minimized in number and effects. The new ships will be fitted with two masts, with two fighting tops upon each. Each top will carry three 3-pounder quick-fire guns, with the necessary magazines and equipments. The mainmast will be fitted with a steel derrick 56 ft. long, for lifting the heavy boats into their positions on the skid beams over the upper deck. Each mast will also carry on a platform at its head a powerful electric light for signaling and searching purposes. The complement of boats is eighteen, four of which are steamboats, and will be capable of acting independently of the ship for purposes of torpedo attack, and four of the lighter boats will be carried on davits of special construction, which will enable them to be lowered at a moment's notice. The main and auxiliary condensers are formed of brass throughout, and possess a cooling surface of 13,500 square feet and 1800 square feet respectively.

In a comparison with the Charlemagne, the first feature that strikes one is that displacement and indicated horse power are nearly reversed as to their relative proportions; but, of course, the extra-engine power of the French vessel is mainly required for the third propeller, and we cannot admit that the result of experiments with triple-screw vessels is so satisfactory as to cause us a feeling of regret that more powerful engines have not been designed for the Magnificent class. At the same time if 18 or 18½ knots is got out of the Charlemagne by applying all her screw power, it will give her manœuvring qualities superior to those of the British battle-ships. This remains, however, to be proved.

The double-armored decks of the Charlemagne are a valuable modification, and the cofferdam between them may prove to be a most useful adjunct to the water-tight qualities of the ship; but it seems to us that, if the stability of the vessel was not disturbed by the arrangement, the two decks would have been more effective combined in one thickness. The turtle-back deck of the Magnificent, stretching from bow to stern, and reaching down far over the sides amidships, with its four inches of steel, is superior, we believe, to the French cofferdam.

The method by which axial fire ahead and astern has been secured appears so likely to be detrimental to the safety of the vessel's upper works when the guns are trained directly fore and aft, that we cannot recommend it. But the plan of securing the upper deck battery of

5½-in. guns behind a complete belt of 3-in. armor cannot be too highly approved. The conning towers are also well placed and at a commanding altitude, though it is a little difficult to understand what security is afforded to the officers in the forward one, in the event of the mast being shot away upon which it is perched, the latter not being armored.

The power of the armament mounted upon the Magnificent is incomparably superior to that of the French vessel. The twelve 6-in. quick-firers upon the former, each with its isolated casemate protected by 6-in. steel, and the sixteen 12-pounder quick-firers of the new Elswick pattern, compose an auxiliary armament so tremendous in its potency that no moderate-sized cruiser could live in the vicinity of the battle-ship, even if keeping under weigh at a rapid rate of steaming, so as to avoid the fire of the main armament of 12-in. heavy guns. The uniform height, 27 ft., of the British heavy guns above the water-line is also a distinct advantage.

The total coal capacity, and consequent radius of action of the British battle-ship, is considerably greater than that of the Charlemagne. Eighteen hundred tons of coal can, in emergency, be stowed away in the former, but the extreme capacity of the latter is only 1100. This is an important characteristic for long sea voyages.

THE TORPEDO-BOAT DESTROYER BRUIZER.

On March 28, in boisterous weather, a full-speed official trial was run of the last of the torpedo-boat destroyers which Messrs. Thornycroft & Co. have built for the Admiralty. The trial was not notable on account of the speed attained, but that is simply on account of the high standard which the builders themselves have raised for these remarkable craft. A short time ago 28 knots, which the Bruizer all but attained on her three hours' run, would have been looked upon as phenomenal; but it has been exceeded by about a knot in the sister vessel, the Boxer, also constructed at the Chiswick yard.

The Bruizer is 201 ft. 6 in. long and 19 ft. wide; she is 13 ft. deep, and her maximum draught is 7 ft. 4 in. at trial draught. The displacement of the vessels of this class is about 220 tons. The engines are similar to those of the Daring. These engines are of quite novel design, and now the trials of the five destroyers in which they have been fitted are complete, it is satisfactory to learn that the engines have given no trouble throughout. The same may be said of the water-tube boilers which have been fitted in these vessels. There have been run, in all, 23 full-speed trials of these vessels, and there has not been an accident or mishap through the failure of the boilers throughout. The fact is of interest in view of the controversy now going on on the subject of water-tube boilers. The enormous test that the machinery of these high-speed craft is put to on full-speed trials must be remembered in connection with this subject. The Bruizer has three Thornycroft boilers placed in two stokeholds. A modified design of Daring boiler is used, the arrangement being the same as that adopted in the Ardent, by which an addition to the heating surface is obtained by a somewhat different disposition of the tubes in the rows next to the casing. The Daring had 8892 square feet of heating surface and 189 square feet of grate surface.

The engines of all these vessels are of the three-stage compound type, each set having high-pressure cylinders 19 in. in diameter, intermediate cylinders 27 in. in diameter, and two low-pressure cylinders each of 27 in. diameter. The stroke is 16 in.

In the Speedy a new device was tried for controlling the distribution of the feed in the water-tube boilers with which that vessel was fitted. It is this question of feed distribution which was so long the rock ahead for the water-tubists when an attempt was made to run these boilers in groups. It was argued, not without reason, that in steam generators of this sensitive nature, and with so small a water-holding capacity, unless the feed were very evenly distributed, disaster would follow. In order to avoid this various devices have been tried, with more or less success. That introduced by Messrs. Thornycroft consists of a hollow steel float, capable of withstanding the boiler pressure, which is placed inside the separator or steam-connecting cylinder which forms so important a feature in the Thornycroft boiler. By a system of levers, somewhat too complicated to describe without the aid of diagrams, the float regulates the opening of a check valve which is placed within the boiler, the amount the valve is opened determining the volume of feed. In this way the water-level in the boiler determines the amount of feed admitted; thus, if the water level falls, the check valve is thrown wider open; if it rise the check valve is closed. Unlike most gears of the kind, the motion of the float has not to be conveyed to the exterior of the boiler through a stuffing box. An arrangement of the latter nature must lose much of its sensitiveness, and herein the Thornycroft gear has a manifest advantage. There is, however, in this device a means of regulating the normal water level by hand, and this is effected through a rod which passes outside the separator through a stuffing box and is worked by a hand wheel. In this way the gear may be set so that the water level can be carried at any required height. The gear has, we hear, been found in practice to act admirably, and we understand it is contemplated using it in some vessels built by other firms. On the occasion of the Bruizer's trial on March 28, the feed water between the three boilers was properly distributed by it, the report being that no hand adjustment was required throughout.

The Bruizer differs from the earlier vessels of this class in having solid manganese bronze propellers. It has long been the practice of the torpedo-boat builders to forge the propeller blades separately and key them into a boss. This plan answered well so long as steel blades only were used, but when manganese bronze was required it was found there was danger of the blades getting loose in the boss. In order to avoid this, a new method of keying it was devised, but it is now thought desirable to have the propellers cast in one. The screws of the Bruizer are three-bladed, all surfaces being polished.

The furnace doors are fitted with springs so as to be self-closing, and the ash-pit doors being self-closing there is less danger to the stokers in case of a burst tube, as the steam would go up the chimney.

At the conclusion of the speed trials, circles were turned on both hands. The circle with helm to port was accomplished in 1 minute 46 seconds, with the helm to starboard in 1 minute 52 seconds. This was in a strong wind, the force being 5 to 6. The weather was too rough to make circles astern, so that part of the trial is reserved for another time.

THE BANSHEE AND CONTEST.

Her Majesty's ships Banshee and Contest, two of the torpedo-boat destroyers building for the British Government by Messrs. Laird Brothers, of Birkenhead, have completed their official trials on the measured mile on the Clyde, and the contractors have to be congratulated on highly satisfactory results. Messrs. Laird have availed to the fullest extent in designing the hulls and machinery of these vessels of their past experience with high-speed ships, with which they have had an unbroken line of successes, including her Majesty's ships Rattlesnake, Onyx, and Renard; the Almirante Lynch and Almirante Condell, for the Chilian navy; the Espora and Rosales, for the Argentine navy; and the machinery they fitted to her Majesty's ships Skipjack and Speedwell; and more particularly they have followed the information obtained in connection with her Majesty's ships Ferret and Lynx, the two torpedo-boat destroyers which they successfully tried and delivered in the summer of last year. The Banshee and Contest are 210 ft. long with 19½ ft. beam, and generally similar in construction to the Ferret and Lynx, which we described in our issue of 7th September last. The armament, however, has been modified, and now consists of one 12-pounder and five 6-pounder quick-firing guns, two separate torpedo tubes on the deck, and no bow tube, and they are equipped with the latest type of 18-in. torpedoes. The engines are Messrs. Laird's well-known tri-compound type, the cylinders being 19 in., 29 in., and 43 in. in diameter by 18 in. stroke, and it is worthy of notice that all parts of the engines are accessible when working at full speed, and all the starting and reversing gear, etc., is worked from a platform at the forward end of the engine-room. It has been a very satisfactory feature in the machinery of Messrs. Laird's make that they have designed their engines with cylinders large enough to give the required power at a reasonable number of revolutions, and on the trial of the Banshee the average for the three hours was only 345. The boilers are a modified form of the Normand type, and no difficulty was experienced throughout the three hours' trial in maintaining the steam at the intended pressure. There was no indication of priming either on the official or preliminary trials.

The official trial of the Banshee took place on Thursday, February 21st. The three hours' trial was commenced at eleven o'clock, the vessel having on board her full normal weight, and the average speed for the whole time was found to be 27.6 knots, or 31.8 miles per hour, with 345 revolutions. After the run the usual trials as to manœuvring were made. The helm was put from hard over to hard over both ways in less than ten seconds, each at full speed, and the steering both ahead and astern was proved to be entirely satisfactory. The trial of the Contest was made under similar conditions the following day, and the mean speed for the three hours was 27.4 knots, with 350 revolutions. There was a remarkable absence of vibration when running at full speed, and no hitch of any kind occurred in the machinery. The seagoing qualities of these boats are perhaps as interesting as the mere speed. An illustration of their success in this direction has been afforded by the Banshee and Contest. The first left Birkenhead under easy steam at 3 P. M. on Friday, February 14th, and reached Greenock at 3 o'clock next morning, in spite of a heavy southeast gale which prevailed from the Mull of Galloway onwards.

The Contest left Birkenhead on February 19th, at 7.15 A. M., and reached Greenock at 4.50 the same afternoon—over twenty knots average—and the vessels were got ready for trial and all the weights adjusted as recorded above. Messrs. Laird only received the order for these boats in February of last year, and the rapidity with which they have been brought forward for trial is highly creditable, and it showed great confidence in the machinery to make the trials of two such boats on successive days, especially as the Banshee had only been twice and the Contest only once under weigh before leaving the Mersey to make their trials. The third boat of the lot is named the Dragon, and is now ready for steam, and will be tried very shortly.

THE ROCKET AND SHARK.

While such high speeds as 28 knots were attained with these and the other vessels constructed by Messrs. James and George Thomson, Limited, Clydebank, on experimental runs, the firm, on the official trials which have just been concluded, contented themselves by just exceeding their guarantee. Thus, having ascertained that 396 revolutions per minute insured 27 knots under all conditions of weather and full displacement, they decided not to go far beyond this. The mean results of the six runs on the measured mile, three in each direction, may be thus tabulated:

MEANS OF SIX RUNS ON MEASURED MILE.

	Rocket.	Shark.
Date of trial	Feb. 27.	March 1.
Air pressure in stokehold	3.5 in.	3 in.
Steam pressure at boilers	188 lbs.	184 lbs.
Revolutions, port engine	399	400
Revolutions, starboard engine	397	397
Vacuum	25 in.	25 in.
Speed of boat	27.7 knots.	27.5 knots.

On the three hours' run in the Firth, with full weights on board, indicator diagrams were taken every quarter-hour, and the results were as follows, the speed being determined by the mean revolutions of the engines:

	Rocket.	Shark.
Revolutions of engines	396	401
Speed of boat	27.4 knots.	27.6 knots.
Indicated horse power	4200	4250

One feature of special note is the wave line. The Rocket and her consorts have an exceptionally fine entry, with a flat floor and little tumble home amidships. The stem is straight. In this respect she differs from some of the earlier craft, which had a torpedo-ejecting tube firing straight ahead; but it was found in practice that the impact of the torpedo on the water retarded it so much as to cause the destroyer, when steaming 27 knots, to overrun it. The later vessels, therefore, have only a double torpedo launching gun on deck, and the

change has enabled greater accommodation to be provided for the crew, under the turtle-decked forecastle-head, where there will be mounted a 12-pounder quick-firing gun over the conning tower, with two 6-pounder guns on either side behind the shelter of the forecastle. The deadwood between the outboard propeller shafting is cut away, so as to afford a freer flow of water to the twin propellers, which are of manganese bronze. The rudder is of the usual type, supported on the usual pintle, the lesser depth being compensated for by greater width.

The machinery consists of two sets of triple-expansion engines. All the working parts are of forged steel and are balanced. The cylinders are supported on steel columns, thoroughly braced, the condenser being separated. The engines were run at a high speed in the erecting shop to ascertain the efficiency of the balancing, and the results on trial were satisfactory. The high-pressure cylinders are 18⅛ ins. in diameter, the intermediate 26⅝ in., and the low pressure 40¼ in., the stroke being 1 ft. 6 in. The piston speed on trial was therefore about 1200 ft. per minute.

There are four water-tube boilers of the Normand type, but it may be here stated that they have two water drums on either side, with the fire-grate between, and from these two drums there are tubes extending in curves of many forms to a central steam drum on the top, the tubes entering in the lower part of the steam receiver or below the water level. The tubes in the rows nearest the fire are of steel, the others are of copper. At the back of the grate the tubes are so curved as to partly close in the furnace end, and in addition the tubes are arranged to prevent the hot gases escaping before the greater portion of the heat has been absorbed. The outside walls consist of galvanized steel tubes. The boilers practically occupy the full size of the compartments, which are covered with a heat-resisting substance placed under the deck. The grate area is 163 square feet and the heating surface 8600 square feet, so that the power was equal to 26.07 indicated horse power per square foot of grate area and to 1 horse power per 2.02 square feet of heating surface. The two center boilers have a smoke-stack in common, while the forward and after boilers have separate funnels smaller than the center funnel. The engines are abaft the boiler compartments.

[SPAIN.]

THE EMPERADOR CARLOS V.

There was launched on March 12, at Cadiz, a first-class protected cruiser for the Spanish Navy.

The displacement of the vessel will be, in sea trim, 9089 tons, the length between perpendiculars being 380 ft., and over all 404 ft. 9 in., the beam 67 ft., and the draught 24 ft. forward, 26 ft. aft and 25 ft. mean. The hull has been built by Messrs. Vea Murgia and Co., Siemens-Martin steel being used, and there is side armor 2 in. thick, 1 in. of Siemens-Martin steel, and the other inch of chrome steel. The protective deck is of steel, the maximum thickness being 6⅛ in., made up of three plates. The armament consists of two 28-centimeter Hontoria guns, eight 14-centimeter Hontoria quick-firing guns, four 10-centimeter and two 7-

centimeter quick-firing guns, four 57-millimeter and four 37-millimeter Nordenfelt guns, two machine guns (mitrailleuse), and six Schwartzkopff torpedo tubes.

The twin engines are of the four-cylinder triple-expansion type, there being two 25-in. high-pressure cylinders, two 77 3-16-in. intermediate, and four 82 3-32-in. low-pressure cylinders, the piston stroke being 45 5-16-in. Steam at 147 lbs. pressure is supplied by 12 single-ended boilers, 16 ft. 3⅝ in. in diameter by 9 ft. 10⅛ in. long. Under natural draught the power to be developed is 15,000 indicated horse power, and under forced draught 18,500 indicated horse power, the speed being, under the former conditions 19 knots and under the latter 20 knots. The screw propellers, which are of bronze, have each four blades. The vessel has bunker capacity for 1771 tons, which gives her a radius of action of 13,000 sea miles at 10 knots. The machinery was constructed by the Maguinista Terrestre y Maritima, Barcelona. The cost of the vessel is about $3,400,000.

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[AMERICAN.]

ARMY AND NAVY JOURNAL.

APRIL 20. Lessons of the Yalu.

APRIL 27. Advantages of Double Turrets. Modern Warships. The Chinese Surrender.

MAY 25. Lessons of the Chino-Japanese War.

ARMY AND NAVY REGISTER.

MAY 4. More Excellent Armor.

MAY 25. Naval Small Arm Adopted.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

MARCH. Constitution and List of Members.

THE AMERICAN ENGINEER AND RAILROAD JOURNAL.

APRIL. Physical Reasons for Rapid Corrosion of Steel Boiler Tubes. Some Facts Relating to Certain Types of Water-tube Boilers. The Cruiser Cincinnati. Tests of the Pneumatic Guns.

MAY. Water Tube Boilers in the British Navy. Some Experiments on the Efficiency of Air Propellers.

AMERICAN CHEMICAL JOURNAL.

APRIL. Argon, a New Constituent of the Atmosphere, by Lord Rayleigh, Sec. R. S., and William Ramsay, F. R. S. On the Spectra of Argon, by William Crookes, F. R. S., etc. The Liquefaction and Solidification of Argon, by K. Olszewski, Professor of Chemistry in the University of Cracow. On the Atomic Weight of Argon, by Edward W. Morley.

The symbol A has been proposed for argon on the supposition that it is an element which is not definitely proven, its spectrum consisting of two distinct combinations of lines.

BULLETIN OF THE AMERICAN GEOGRAPHICAL SOCIETY.

VOLUME XXVII., No. 1, 1895. Korea and the Koreans. The Mapping of New York State. Reports of a Conference on Geography. The United States Geological Survey in 1894.

CASSIER'S MAGAZINE.

MAY. The Telephone and Its Operation. Telegraphy as It Used to Be. American Coast Defense Mortars. A History of the Telephone.

ENGINEERING NEWS.

MAY 2. The Location of the Nicaragua Canal. Legal Electrical Units in the United States.

MAY 9. The French Aluminum Torpedo-boat.

IRON AGE.

FEBRUARY 28. The Uehling and Steinbart Pneumatic Pyrometer. Reduced Harveyized Armor Plate.

MARCH 7. The Great Gun Magnet. Tests of Non-conducting Pipe Coverings.

MARCH 14. The Higgins Plate Roller Bending Machine.

MARCH 21. The Bristol Recording Ampère Meter. Southern Coal Tests by the Navy Department. Electric Annealing of Armor Plate. Naval News.

APRIL 11. The Carnegie Armor Plate Test.

The Navy Department at Washington has issued the following statement of the present condition of the new United States war vessels. The figures represent the percentage of completion: Amphitrite, 99 per cent.; Maine, 98 per cent.; Terror, 96 per cent.; Texas, 95 per cent.; Indiana, 93 per cent.; Massachusetts, 90 per cent.; Katahdin, 90 per cent.; Oregon, 89 per cent.; Puritan, 87 per cent.; Monadnock, 85 per cent.; Brooklyn, 42 per cent.; Iowa, 35 per cent.; Gunboat No. 7, 31 per cent.; Gunboat No. 9, 26 per cent., and Gunboat No. 8, 25 per cent. Since January 1 the Minneapolis, Cincinnati, Raleigh, Olympia, and Ericsson have been taken from the list of uncompleted ships. All have been commissioned and put into regular service except the Ericsson. The Amphitrite will be commissioned next week, leaving but 14 naval vessels under construction.

APRIL 25. The Sprague Electric Locomotive. Defects in Steam Boilers, III.

MAY 2. Captain Eardley-Wilmot on the United States Navy.

JOURNAL OF THE MILITARY SERVICE INSTITUTION.

MARCH. Discipline: Its Importance to an Armed Force, and the Best Means of Promoting and Maintaining it in the U. S. Army. Preliminary Examination: West Point. The Place of Physical Training in the Military Service. The Royal Artillery College at Woolwich. The Infantry Drill Regulations Systematized and Simplified. Comment and Criticism. The Military Academy and the Education of Officers.

"One essential truth must be borne in mind, namely, that all educational institutions of the highest order are growths and not Minerva-like creations."—[Prof. Charles W. Larned, U. S. M. A.]

"West Point does not educate anybody. That is impossible in four years at any liberal institution. What, from an educational standpoint, it does and successfully is to give the cadet the basis of an education." —[First Lieut. W. E. Birkhimer, Adjutant, 3d U. S. Artillery.]

Range and Position Finding. The War between China and Japan.

MAY. A Paper on Military Libraries. The Relation of Hygiene to Military Efficiency. The Army Artillery Reserve. Training of the American Soldier. Results of Experimental Firing with the Service Rifle (Model of 1894). Battery Competitions for Gunners. The United States Marine Corps. Value of the Fire of Dismounted Cavalry. "The Right (or Left) Turn" of the Infantry Drill Regulations. Comment and Criticism. Reprints and Translations.

JOURNAL OF THE UNITED STATES CAVALRY ASSOCIATION.

MARCH. High Explosives and Intrenching Tools in their Relation to Cavalry.

JOURNAL OF THE FRANKLIN INSTITUTE.

MARCH. The Animal as a Prime Mover, Part III., by R. H. Thurston. Action of a Single Phase Synchronous Motor. Water Purification. Science in the Foundry.

APRIL. The Redheffer Perpetual Motion Machine. The Rise and Progress of River and Harbor Improvement in the United States. The Atomic Weight of Tungsten. The Reduction of Alumina from a Thermo-chemical Standpoint.

JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES.

JANUARY. Tests of Non-conducting Pipe Coverings.

SCHOOL OF MINES QUARTERLY.

JANUARY. Theory of Electro-metallurgy.

THE UNITED SERVICE.

MARCH. The Supply of the Armies of Frederick the Great and Napoleon. The Story of Alcatraz. Origin and Developments of Steam Navigation (continued).

APRIL. The Supply, etc. (continued). Yesterday in Annapolis. Origin, etc.

MAY. The Supply, etc. (concluded). Origin, etc. (concluded).

[FOREIGN.]

ENGINEER.

No. 2042, FEBRUARY 15. Report on a Pumping Engine at Hornsey Sluice. Destruction of Chinese Warships at Wei-Hai-Wei. Priming and Governing Engines.

FEBRUARY 22. The New Elswick Eight-inch Quick-fire Gun.

MARCH 1. Trial Trips of the Banshee and Contest. Electric Light Engines and Dynamos, S. S. Caledonia.

"It has a drum armature rotating between the poles of a vertical horseshoe magnet, and will give an output of 220 amperes at 105 volts when running at a speed of 220 revolutions per minute."

MARCH 8. The Utilization of Niagara. The Admiralty Distribution of Engineers in the Fleet.

MARCH 15. The Navy Estimates. Static Friction.

MARCH 29. The Battle-ships Magnificent and Charlemagne—a Comparison.

APRIL 5. Elements of Force in a Warship (Inst. Naval Architects).

APRIL 12. First-Class Battle-ships and Bilge Keels.

"To sum up, then, the bilge keel has proved itself to be an instrument capable of reducing the extent of rolling from 50 to 70 per cent.; of accelerating the process of extinction of rolling sixfold; of increasing the rolling period so as to enhance steadiness; of developing to its fullest extent the value of headway in assisting steadiness, and of reducing materially the tactical diameter in turning, as well as improving steering properties, whilst speed is uninjured and coal endurance not affected. The result of these experimental trials is therefore phenomenally satisfactory."

APRIL 19. British Fuzes for Modern Guns.

ENGINEERING.

No. 1520, FEBRUARY 15. The New Nordenfelt Guns. The Pneumatic Pyrometer. The Cost of Vessels of the Naval Defense Act.

FEBRUARY 22. The New Nordenfelt Guns (continued).

MARCH 1. The New Nordenfelt Guns (continued). The Naval Manœuvres (1894).

MARCH 8. The New Nordenfelt Guns (continued). Short Air-Space Dynamos. The Torpedo-boat Destroyers Rocket and Shark.

MARCH 15. A Review of "Elementary Naval Tactics," by Commander William Bainbridge-Hoff, U. S. Navy.

"The United States Navy is fortunate in possessing officers who are not merely good sailors and brave men, but are also acute and able thinkers, and have the power of expressing their ideas in clear, concise and forcible language. The system of education in the American Navy is perhaps better adapted than our own for creating a corps of officers who will be men of thought as well as men of action; and one natural outcome of it is seen in the many erudite and exhaustive books and papers upon naval questions which come from the pens of American naval officers. Their literary work appears to be marked by more thoroughness, better balance and greater power of thought, analysis and expression than we in this country are accustomed to expect from naval authors."

The New Nordenfelt Guns (continued). The Navy Estimates.

MARCH 22. The New Nordenfelt Guns (continued). The New Spanish Cruiser Emperador Carlos V. The Navy in Parliament.

MARCH 29. The New Nordenfelt Guns (continued).

APRIL 5. Torpedo-boat Destroyers. Our Battle-ships (Notes on Further Experience with First-class Battle-ships), by Sir William White, Director of Naval Construction (British).

"The Resolution (without bilge keels), by orders from the Admiralty, had been purposely kept in very nearly the same condition of stability as the Repulse. Comparing the returns from these two ships, it appears that the Resolution on one occasion reached a maximum inclination to the vertical of 23 deg.; whereas the Repulse never exceeded 11 deg. The mean angles of oscillation were, of course, considerably below these maxima, probably about one-half. The Royal Sovereign and Empress of India were also in company. The condition of coal storage in these two ships at the time gave them greater stiffness and a quicker period, which, under the conditions of weather and sea, caused rather heavier rolling than in the Resolution.

In view of this experience, although the trial was limited and not representative of many conditions occurring at sea, it was decided to fit all the other ships of the class with bilge keels similar to those which had proved so effective in the Repulse. This work was completed for the ships of the Channel Squadron during their annual refit last summer; it has since been carried out in all the other ships of the class.

On the cruises of the Channel Squadron which have taken place since bilge keels were fitted there have been but few opportunities of obtaining proof of their practical value. So far as experience has gone, however, there is a consensus of opinion amongst officers in command that rolling has been greatly reduced by the bilge keels."

H. M. S. Bruizer.

JOURNAL OF THE ROYAL UNITED SERVICE INSTITUTION.

MARCH. Battles of Chillianwallah and Goojerat. The New Harbor at Biserta, with Plans.

APRIL. Sir George Rooke, Admiral of the Fleet. Collapsible Boats and Pontoons for Military Purposes, by the Rev. E. L. Berthon. The Hydraulic Gun-mounting of French Ships.

MINUTES OF PROCEEDINGS OF THE INSTITUTION OF CIVIL ENGINEERS.

VOLUME CXIX., 1894-95, Part 1. The Machinery of Warships. Indian River Steamers. The Filtration of the Müggel Lake Water Supply, Berlin.

PROCEEDINGS OF THE ROYAL ARTILLERY INSTITUTION.

FEBRUARY. A Method of Calculating the Probability of Coast Defense Fire. A Plea for Heavy Guns in Fortress Defense. Notes on German Manœuvres.

MARCH. The Story of the Civil War in America (A Review). General Bourbaki's Campaign in January and February, 1871. The Resistance of the Air at High Velocities, by Captain Zabudski, Russian Artillery (Translated from the Russian).

Captain Zabudski uses Krupp's tables in his calculations to continue Mayevski's laws.

With the metre and kilogramme as units:

From $v = 1000$	**m. s. to** $v = 800$	**m. s., resistance**	$= q = 0.7130\pi R^2 \frac{\delta}{\delta_0} v^{1.86}$,
800 " "	550 " "	$q = 0.2616\pi R^2 \frac{\delta}{\delta_0} v^{1.79}$,
550 " "	419 " "	$q = 0.0394\pi R^2 \frac{\delta}{\delta_0} v^2$,
419 " "	375 " "	$q = 0.0^4940\pi R^2 \frac{\delta}{\delta_0} v^3$,
375 " "	295 " "	$q = 0.0^3670\pi R^2 \frac{\delta}{\delta_0} v^3$,
295 " "	240 " "	$q = 0.0^4583\pi R^2 \frac{\delta}{\delta_0} v^3$,
240 downwards		"	$q = 0.0140\pi R^2 \frac{\delta}{\delta_0} v^2$,

Where R is the radius of the cylindrical part of the projectile in metres, δ is the density of the air during the experiment, and δ_0 is the standard density of 1.206 kilogrammes per cubic metre.

Captain Zabudski calculates the values of his ballistic functions between 600 m. s. and 1000 m. s. by the equation $q = 0.5091\pi R^2 \frac{\delta}{\delta_0} v^{1.8}$; which is sufficiently approximate.

APRIL. Coast Artillery in Action. Torpedo-boat Raids on Harbors.

STEAMSHIP.

MAY. The New First-Class Cruisers (British).

Provision is made for the commencement of four new first-class cruisers in the navy estimates for 1895-96. The principal dimensions are: Length between perpendiculars, 435 ft.; on water-line, 455 ft.; breadth, 69 ft.; mean draught with keel, 25 ft. 3 in.; displacement about 11,000 tons. The measured mile speed, natural draught, will be about 20½ knots.

THE UNITED SERVICE GAZETTE.

NO. 3240, FEBRUARY 9. The Navy League. China and Japan. The Tactics of the Corean War, by Vice-Admiral P. H. Colomb.

"The results of the Yalu battle were the same as that of the battle of the Nile. The Chinese had no business to send a great fleet on a secondary expedition. If competent to contend for the command of the sea, it might have been used for that purpose, and no other; if not competent, it ought to have been kept intact to make it more difficult for the Japanese to follow up with attacks upon territory."

FEBRUARY 16. China and Japan. What is a Sufficient Navy?

FEBRUARY 23. The Halpine Dirigible Torpedo. Naval Reserves.

MARCH 2. The Naval Manœuvres, 1894. How Can the Navy be Made Ready for War? Fighting on the Niger.

MARCH 9. The Navy Estimates, I. The Army Estimates. Heavy Guns in Fortress Defense.

No provision is made in the Navy estimates for the commencement of any new battle-ship in the coming financial year.

MARCH 16. The Navy Estimates, II. Naval Policy. The Organization of the Navy for War.

MARCH 23. The Royal Dock Yards; New Programme for Work. The Requisite Strength of the British Navy.

APRIL 6. Our Strategic Position in the Mediterranean. The Chitral Expedition.

APRIL 13. Warship Construction. Torpedo-boat Destroyers.

APRIL 20. Messenger Pigeons in Connection with Coast Defense (a summary of the paper published in No. 72 of the Proceedings U. S. Naval Institute). The Fighting Coefficients of a Warship.

APRIL 27. The Navy as the Empire's Representative. The "Times" and the War Office.

MAY 4. The Navy Boiler of the Future. The "Times" and the War Office, II. J. H. G.

LE MONITEUR DE LA FLOTTE.

FEBRUARY 2. The New Minister of Marine, Vice-Admiral Besnard.

FEBRUARY 9. The Madagascar Transports.

FEBRUARY 16. The Re-establishment of the French Board of Admiralty. The Extra-Parliamentary Naval Committee.

FEBRUARY 23. The Creation of a List of Commands.

MARCH 2. The Growing Importance of the German Navy.

MARCH 9. Our Navy at Kiel.

MARCH 16. French and English Battle-ships. The Naval Estimates.

MARCH 23. The Discussion of the Navy Estimates.

MARCH 30. Running Lights.

"The question of safety of navigation is one of daily recurrence, which recent disasters have only served to intensify. Rear-Admiral Galoche, in an article in the La Marine Française, proposes a change which he thinks will tend to remedy the insufficiency of the existing running lights. In the proposed system the light at the masthead, instead of a sector of 10 points of white light on each side, will only have a white sector of 4 points, continued by a sector of 6 points of green light on the starboard side and a sector of 6 points of red light on the port side.

The immediate results of the use of this tri-color masthead light can be easily conceived. 1st. When a vessel sights another showing a white and colored light, the first will be inside of 45° of the other's course, reckoning the bearing from right or left, according to the color of the side light. 2d. When in the presence of a vessel showing two lights of the same color one will find himself outside of the 45° of the route of the stranger and consequently in no danger of a collision. If, being in the first position, a manœuvre is made which will bring out the lights of the second position, a feeling of safety will at once follow. If, on the contrary, finding oneself in the second position (*i. e.* with two lights of the same color in sight), a manœuvre will bring in the white sector, it is presumable that the ships are approaching one another. Thus the simple use of a tri-color light, easy of construction and management, diminishes notably the sector of the possible routes of a ship in sight and gives the watch officer the means of reckoning these routes rapidly and *de visu* within far more restricted limits than with the white light."

REVUE DU CERCLE MILITAIRE.

FEBRUARY 2. A Safety Device for Preventing Premature Firing (with sketches). Cavalry Confronted by the New Fire-arms. Long Distance Photography (with sketches) (continued).

FEBRUARY 9-16. The Japanese Army. The Thirteenth French Army Corps in the War of 1870. Long Distance Photography (ended).

FEBRUARY 23. The Lefebvre Carriages and the Madagascar Expeditionary Corps. Ice-shoeing of Horses in Sweden and Norway.

MARCH 9. Madagascar: Its Geography, Climate, Population and Productions. The Lefebvre Conveyance, and the Madagascar Expeditionary Corps. The Thirteenth Army Corps in the War of 1870 (continued).

MARCH 16-23. Medical Statistics of the French Army for 1892. Madagascar, etc. (continued). The Thirteenth Army Corps, etc. (continued).

MARCH 30. The Holy City of Moukden. The Thirteenth Army Corps, etc. (continued).

REVUE MARITIME ET COLONIALE.

JANUARY. The Naval Battle of Yalu, according to the Latest French and Foreign Informations, by Lieut. Lephoy, of the French Navy. In what Consist our Armored Battle-ships, and their Worth. The Cruiser Volta in China and Tonkin (1883-85). Chemical and Micro-biological Researches in the Alterations and Protection of Common Metals in Salt Water. Prizes for the Best Works Published in the Review.

FEBRUARY. The First-class Torpedo-gunboats of the English Navy. A Report on the Process used for Detecting Fraud in Table Oils and in Oils used in Manufacture. A Study of the Modern Mounts for Heavy Ordnance. Geometry of Diagrams (continued).

SOCIÉTÉ DES INGÉNIEURS CIVILS.

JANUARY. Mechanical Traction of Boats on Canals. Electro-Magnetic Towing. A Study of Various Electric Plants in Switzerland and Savoy. Comparative Results of Electricity and Compressed Air in the Mechanical Traction of Tramways.

FEBRUARY. A New Process for Calculating the Strain Sustained by a Latticed Straight Beam Symmetrically Laden and Resting on Two Supports. Annual of 1895 (a supplement to the January number).

LE YACHT.

FEBRUARY 2. The End of the Flying Squadron.

"After giving this method of instruction a two years' trial the naval authority became convinced that its advantages over the old method were not such as to justify its continuation at the greatly increased cost."

Union of the French Yachts: Admissions, Concessions of Flags, etc. Association Technique Maritime: Remarks on the Fire-boxes of Boilers (Daymard).

FEBRUARY 9. The Question of Transportation to Madagascar.

FEBRUARY 16. The Destruction of the Chinese Fleet (E. Weyl). Submarine Telegraphy.

FEBRUARY 23. The Question of Transports.

MARCH 2. Commerce Destroyers (Privateer-cruisers) (E. Weyl). Electricity: Telegraphic Communications without an Intermediary Conductor (Em. Cohen).

MARCH 9. The Question of Battle-ships. The Italian Torpedo-ram Umbria.

MARCH 16. The English Navy Appropriations.

"The amount of the English Navy estimates for 1895-96 is £18,880,021 ($91,379,301), an increase of $6,741,045 over last year's and an increase of about twenty-two and a half millions over the preceding year, besides a supplementary credit of $22,000,000 spent for the purchase of raw material and supplies in order to take advantage of the decline in market prices.

The total personnel afloat in 1895-96 will be 88,850 men, an increase of 5,450 over the present year, which has already an increase of over six thousand over the preceding one. The increase of men is particularly noticeable in the number of machinists, firemen, etc., which is only natural in view of the enormous development of steam power. It may be thus seen that Great Britain, far from thinking of ever abandoning her supremacy of the sea, will at no distant date have an enormous navy so powerfully constituted as to defy the whole naval world combined."

MARCH 23. The Navy in the French Chamber of Deputies.

"In 1891 the High Council of the Navy fixed the composition of our fighting squadrons as follows: 24 armored battle-ships, 12 first-class

cruisers; 12 second-class cruisers, 12 third-class cruisers, 4 supply transports, 4 torpedo transport cruisers, 2 repair-shop cruisers, 12 cruisers or large torpedo despatch-boats, 40 seagoing torpedo-boats, 45 embarkable torpedo-boats, besides a number of coast defense vessels and a fleet for foreign stations. But in 1894 the High Council, presided over by M. Felix Faure, since elevated to the dignity of President of the Republic, decided that the Squadron of First Class Cruisers should be composed of armored cruisers, the number of which should be raised to twelve by the construction of six additional vessels of the type of the Dupuy-de-Lôme, with displacements of not more than 8000 tons, keeping in view (1) Radius of action; (2) Speed; (3) Offensive power, and, finally, Defensive Power. The number of second-class cruisers being now complete owing to the disrating of protected cruisers ranking at present as first-class, none will be built till 1904. Supply transports and repair-shop vessels are done away with. The seagoing torpedo-boats having proved inefficient while accompanying squadrons, will be turned over to the mobile defenses as soon as the 220-ton boats are finished. Reductions are also made in the number of coast defense vessels, besides other secondary modifications of the original plans. This will involve an expenditure of about 214,200,000 francs, distributed over a period of nine years."

Launching of the Spanish Armored Cruiser Carlos V., of 9235 Tons Displacement.

MARCH 30. The Navy in the House of Commons (E. Weyl). The Bulb-keel. Launching of the Russian Imperial Yacht Standart.

RIVISTA DI ARTIGLIERIA E GENIO.

VOLUME I., JANUARY. Notes Relative to the Theory of the Resistance of Straight Beams Subjected to Longitudinal Pressure. Progress and Regress of the Infantry Rifle. On the Factors of Fire through Quadratic Resistance. On the Probability of Fire in Coast Artillery.

FEBRUARY. A Glance at the European Small Fire-arms.

In a lengthy article on the modern rifle, the writer states that no nation can boast of a weapon really superior to that of another, but still he thinks a preference may be given to the Mauser, Roumanian model of 1893, 6.5 mm. calibre. The general tendency to decrease the calibre of the gun has induced France, though possessing a superior weapon in the Lebel, to replace the latter by the Dauteteau rifle of 6 mm.

MARCH. A Table of Fire (v. Fattori di tiro in the preceding Vol.). A Few Observations in Regard to the Manuals of Temporary Fortifications. The Characteristics of Coast Firing. The Actual State of the Question of Field Guns.

RIVISTA MARITTIMA.

VOLUME II., FEBRUARY. Erosion in Steam Boilers and Ship Bottoms. A History of the Italian Navy from the Time of Cosmo I. and his Immediate Successors. Coastwise Navigation in the Adriatic Sea.

The writer laments the fact that the coast trade of this pre-eminently Italian sea is practically carried on by Austrian shipowners.

REVISTA TECNOLÓGICO-INDUSTRIAL.

FEBRUARY. Analysis of the Flour of Commerce (ended). An Aluminum Torpedo-boat.

MARCH. Something on Hydraulics. Inter-urban Telephones in Spain.

REVISTA MARITIMA BRAZILEIRA.

JUNE, 1893—DECEMBER, 1894. Reorganization of the Brazilian Navy.

JANUARY, 1895. Autobiography of a Whitehead Torpedo (v. preceding No.). Construction of Guns of the Armstrong System. Reorganization of the Brazilian Navy (continued). J. L.

ANNALEN DER HYDROGRAPHIE UND MARITIMEN METEOROLOGIE.

ANNUAL SERIES XXIII., VOLUME I. Electrical Communication between Lightships and the Coast. (A Brief Description of Bedwell's Patent Mooring Swivel.) Meteorological Phenomena on the East Coast of Africa. Description of the East Coast of Africa from the Mouth of Umba River to Ulenge Island. Sailing Directions for Moa Bay. Sailing Directions for Mansa Bay. The Approach to Para and the Channels of the Amazon. Extracts from the Latest Sailing Directions for Atshin, Sumatra. Petroleum Lights as Aids to Navigation. Some Observations on St. Rosalia, Gulf of California.

Minor Notes: Climate on the S. W. Coast of Africa; Meteorological Journals Received at the German Observatory in December, 1894.

Weather Report of the German Coast for December, 1894.

VOLUME II. Voyage from Apia to Singapore. Survey of the Harbor of Lindi, East Coast of Africa. Test of the Pintsch System of Gas-buoys. Review of the Weather in Germany during 1894. Criticism of V. Kurs' Work on the Navigable Waterways of Germany. Barca Quebrada and Braxilito, Costa Rica.

Minor Notes: Meteorological Journals Received at the German Observatory during January, 1895. Weather Report for January, 1895.

DEUTSCHE HEERES-ZEITUNG.

JANUARY 30. To My Army—Address of Emperor William on the Twenty-fifth Anniversary of the Franco-German War. Pioneer Regulations for the German Infantry. Strategical and Tactical Review of the Battle near Blumenau-Pressburg, July 22, 1866 (continued).

FEBRUARY 2. Mobilization of the Belgian Army. Strategical and Tactical Review, etc. (concluded).

FEBRUARY 6. French Cavalry Reserve and the Required Horses. Report of General Baratieri on the Capture of Cassala.

FEBRUARY 9. Military Service of the German Public School Teacher. Report of General Baratieri, etc. (concluded).

FEBRUARY 13. Naval Vessels Lost in 1894 (A Review).

FEBRUARY 16. Lecture of Emperor William before the German Military Society.

FEBRUARY 20. Wealth in the German Army. Battle Tactics of Infantry Armed with Modern Arms.

FEBRUARY 23. Archduke Albrecht of Austria. Battle Tactics, etc. (continued).

FEBRUARY 27. The Italian Army in Abyssinia. Battle Tactics, etc. (continued).

MARCH 2. Financial Aid to Officers Retiring from the German Army. Battle Tactics, etc. (continued).

MARCH 6. Progress of the German Navy in 1894. (A review of the vessels completed and of those laid down and in progress of construction.) Battle Tactics, etc. (continued).

MARCH 9-13. Battle Tactics, etc. (continued).

MARCH 16. The Armored Cruiser.

A brief description and comparison of the different types of this class of vessels built by the various naval powers, from which the writer considers that of the cruiser New York as the best type.

Battle Tactics, etc. (continued).

MARCH 20. Battle Tactics, etc. (continued).

MILITÄR WOCHENBLATT.

FEBRUARY 2. Armored Cruisers. (An argument in favor of this class of vessels for the German Navy.) The Mobilization of Two French Reserve Cavalry Regiments in October, 1894.

FEBRUARY 20. Pioneer Service of Infantry. A New Field Gun adopted in France.

FEBRUARY 23. Pioneer Service of Infantry (concluded). Contributions to the History of the Years 1847-48 (concluded).

MARCH 6. The Movement of Field Artillery in Battle. The French Army Budget. New Regulations for the Russian Transport Service in War.

MARCH 9. The Movement of Field Artillery in Battle. The Riding School. Madagascar.

MARCH 13. Madagascar (concluded).

MARCH 20. Reorganization of the Italian Army.

MARCH 27. Cavalry Divisions during Peace. Holland's War on the Island of Lambok in 1894.

MITTHEILUNGEN AUS DEM GEBIETE DES SEEWESENS.

VOLUME XXIII., No. III. Defensive Naval Strategy (The Defense of the Coast), A Study. The Use of Torpedo Nets on Battle-ships. Modern Naval Tactics. The French Battle-ship Brennus. The English Battle-ship Majestic. The English Torpedo-depot Vulcan. Basius' Bateau Rouleur. The English Navy. The English Torpedo-boat Destroyers Boxer and Lynx. The English Sloops Alert and Torch. The German Battle-ship Ersatz Preussen.

This vessel will shortly be laid down at the navy yard, Wilhelmshaven, and it will be an improved Kurfürst Friederich Wilhelm. It will require four years to build her. Harvey armor will be used instead of nickel steel armor. Estimated cost, 20,000,000 marks, of which sum 14,120,000 marks is estimated for the hull and machinery, 5,000,000 marks for the armament and 512,000 marks for the torpedo outfit.

New Common Shell Adopted in the English Navy. Contrivance to Destroy Torpedo Nets. The Use of Aluminum for the Bottom Plating of Ships. Annual Report of the Secretary of the Navy of the United States. Another Plan to Reach the North Pole. Coaling Men-of-War.

Tables giving the rate of coaling from lighters and vessels alongside and when coaling alongside a wharf or mole.

Torpedo-boats for the German Navy.

Four new boats have been recently laid down at Elbing. They will be of the most modern type.

VOLUME IV. The Coast Defense Ships Monarch, Wien, and Budapest of the Austrian Navy.

The first has just been laid down at Pola and the last two at Trieste.

The Bow and Stern of Modern Racing Yachts. The Loss of the Elbe. Foreign Navies in 1894. (A review of the progress made in the various navies during the year.) A Project to Drain the Zuider-See. The Effect of Bilge Keels. The French Battleships Magenta and Hoche. Reconstruction of the Italian Battleship Dandolo. The Russian Armored Cruiser Rjurik. The French Navy. The Monterey. The Necessity of Replacing Wood with some Non-combustible Material in Modern Ships of War. H. O.

REVIEWERS AND TRANSLATORS.

Lieutenant HUGO OSTERHAUS, U. S. Navy.
Lieutenant J. H. GLENNON, U. S. Navy.
Professor JULES LEROUX.

SPECIAL NOTICE.

NAVAL INSTITUTE PRIZE ESSAY, 1896.

A prize of one hundred dollars, with a gold medal, is offered by the Naval Institute for the best essay presented on any subject pertaining to the naval profession, subject to the following rules:

1. The award for the prize shall be made by the Board of Control, voting by ballot and without knowledge of the names of the competitors.

2. Each competitor to send his essay in a sealed envelope to the Secretary and Treasurer on or before January 1, 1896. The name of the writer shall not be given in this envelope, but instead thereof a motto. Accompanying the essay a separate sealed envelope will be sent to the Secretary and Treasurer, with the motto on the outside and writer's name and motto inside. This envelope is not to be opened until after the decision of the Board.

3. The successful essay to be published in the Proceedings of the Institute: and the essays of other competitors, receiving honorable mention, to be published also, at the discretion of the Board of Control; and no change shall be made in the text of any competitive essay, published in the Proceedings of the Institute, after it leaves the hands of the Board.

4. Any essay not having received honorable mention, may be published also, at the discretion of the Board of Control, but only with the consent of the author.

5. The essay is limited to fifty (50) printed pages of the Proceedings of the Institute.

6. All essays submitted must be either type-written or copied in a clear and legible hand.

7. The successful competitor will be made a Life Member of the Institute.

8. In the event of the Prize being awarded to the winner of a previous year, a gold clasp, suitably engraved, will be given in lieu of a gold medal.

By direction of Board of Control.

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